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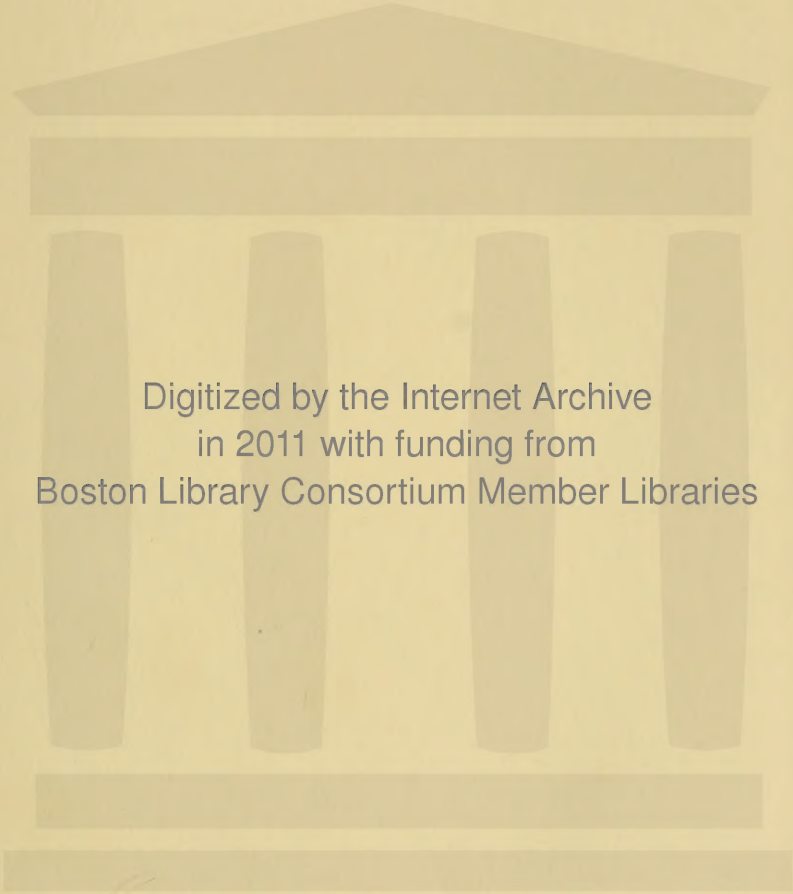

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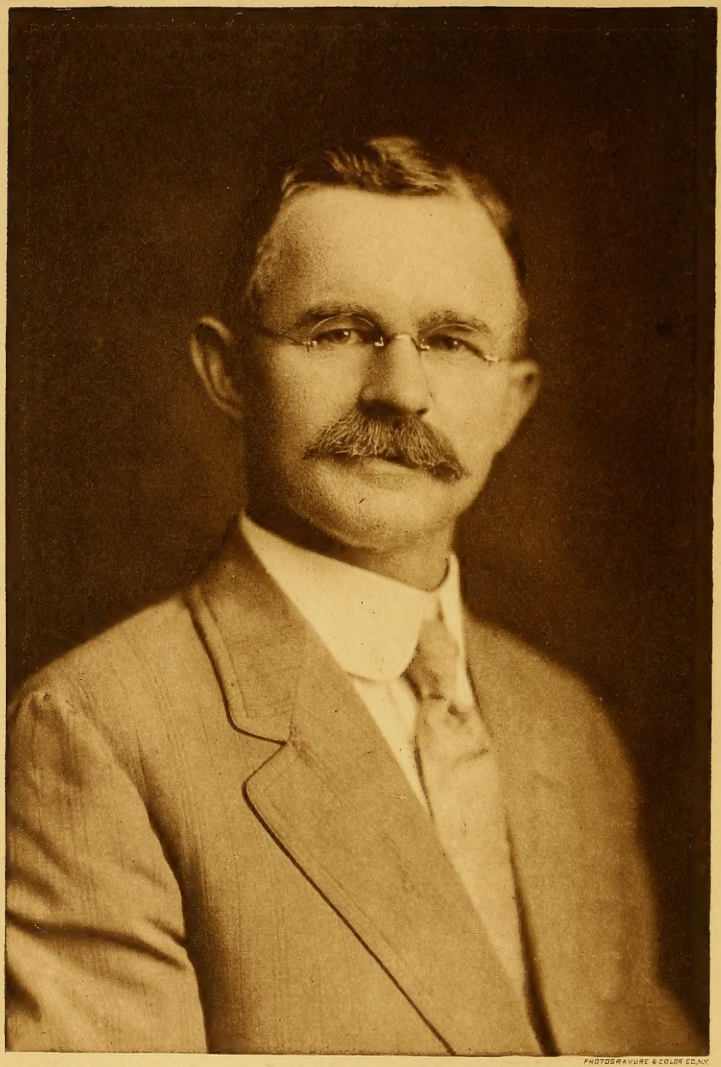

PHOTOGRAVURE & COLOR CO. N.Y.

E. O. Ackerman

PROCEEDINGS

OF THE

AMERICAN ELECTRIC RAILWAY

ENGINEERING ASSOCIATION

1912

CONTAINING A COMPLETE REPORT OF THE TENTH ANNUAL CONVENTION, HELD AT THE INTERNATIONAL AMPHITHEATRE, CHICAGO, ILLINOIS, OCTOBER 7, 8, 9, 10, 11, 1912

PUBLISHED BY THE
AMERICAN ELECTRIC RAILWAY ASSOCIATION
FROM THE OFFICE OF THE SECRETARY
29 WEST 39TH STREET, NEW YORK

PRESIDENT 1911-1912
E. O. ACKERMAN, ENGINEER
MAINTENANCE OF WAY
COLUMBUS RAILWAY AND LIGHT CO.
COLUMBUS, OHIO

PRESIDENT 1911-1912

E. O. ACKERMAN, ENGINEER

MAINTENANCE OF WAY

COLUMBUS RAILWAY AND LIGHT CO.

COLUMBUS, OHIO

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PUBLISHED BY THE
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FROM THE OFFICE OF THE SECRETARY
29 WEST 39TH STREET, NEW YORK, N. Y.

THE NAME OF THIS ASSOCIATION WAS FORMERLY THE

AMERICAN RAILWAY MECHANICAL AND ELECTRICAL ASSOCIATION

ORGANIZED AT CLEVELAND, OHIO, FEBRUARY 16, 1903.

REORGANIZED AT PHILADELPHIA, PA., SEPTEMBER 25, 1905

UNDER THE NAME OF

AMERICAN STREET AND INTERURBAN RAILWAY ENGINEERING ASSOCIATION

THE NAME OF THIS ASSOCIATION IS NOW

AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION

(CHANGE MADE AT 1910 ATLANTIC CITY CONVENTION).

J. B. LYON COMPANY, PRINTERS
ALBANY, N. Y.

621.33.06

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(Officers of the 1912 Convention.)

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H. A. MULLETT, Superintendent of Rolling Stock, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

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(Elected at the 1912 Convention.)

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Engineer Maintenance of Way, Public Service Railway Co.,
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Superintendent of Power and Electrical Engineer,
The Cleveland Railway Co.,
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1903–04.....E. W. Olds.
1904–05.....C. F. Baker.
1905–06.....H. H. Adams.
1906–07.....H. H. Adams.
1907–08.....Fred. G. Simmons.
1908–09.....Paul Windsor.
1909–10.....F. H. Lincoln.*
1910–11.....W. J. Harvie.
1911–12.....E. O. Ackerman.

* Deceased.

CONVENTIONS OF THE ASSOCIATION SINCE ORGANIZATION

1903—Saratoga Springs, N. Y.....September 1–3
1904—St. Louis, Mo.....October 10–12
1905—Philadelphia, Pa.....September 25–26
1906—Columbus, Ohio.....October 15–17
1907—Atlantic City, N. J.....October 14–16
1908—Atlantic City, N. J.....October 13–16
1909—Denver, Colo.....October 5–8
1910—Atlantic City, N. J.....October 11–14
1911—Atlantic City, N. J.....October 9–13
1912—Chicago, Ill.....October 7–11

OFFICERS SINCE ORGANIZATION

OFFICERS, ORGANIZATION MEETING

(American Railway Mechanical and Electrical Association.)

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Superintendent of Rolling Stock, The Milwaukee Electric Railway and Light Co., Milwaukee, Wis.

Second Vice-President:

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Master Mechanic, Rochester Railway Co., Rochester, N. Y.

Third Vice-President:

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Superintendent of Motive Power and Machinery, Boston Elevated Railway Co., Boston, Mass.

Secretary and Treasurer:

S. W. MOWER,

Detroit United Railway, Detroit, Mich.

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The Officers and

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T. J. Mullen, Master Mechanic, Scranton Railway Co..... .Scranton, Pa.
H. H. Adams, Sup't of Shops, The United Railways & Elec. Co...Baltimore, Md.
D. F. Carver, Chief Engineer, The Cleveland Electric Ry. Co....Cleveland, Ohio

Elected at the organization meeting, held in the Hollenden Hotel, Cleveland, Ohio, February 16, 1903.

OFFICERS, 1903-1904

President:

E. W. OLDS,

Superintendent of Rolling Stock, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

First Vice-President:

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Superintendent of Motive Power and Machinery, Boston Elevated Railway Co., Boston, Mass.

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S. W. MOWER,

Detroit United Railway, Detroit, Mich.

EXECUTIVE COMMITTEE:

The Officers and

T. J. Mullen, Master Mechanic, Scranton Railway Co.....Scranton, Pa.
H. H. Adams, Sup't of Shops, The United Railways & Elec. Co...Baltimore, Md.
D. F. Carver, Chief Engineer, Public Service Corporation of N. J..Jersey City, N. J.
H. J. Lake, Master Mechanic, Muncie, Hartford & Ft. Wayne Ry. Co., Muncie, Ind.

Elected at Saratoga Springs, N. Y., September 3, 1903.

*Deceased.

OFFICERS, 1904–1905

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C. F. BAKER,

Superintendent of Motive Power and Machinery, Boston Elevated Railway Co., Boston, Mass.

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Superintendent of Shops, The United Railways & Electric Co., Baltimore, Md.

Second Vice-President:

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Master Mechanic, International Railway Co., Buffalo, N. Y.

Third Vice-President:

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Superintendent of Construction and Maintenance of Way, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

Secretary and Treasurer:

S. W. MOWER,

Detroit United Railway, Detroit, Mich.

EXECUTIVE COMMITTEE:

The Officers and

D. F. Carver, Chief Engineer, Public Service Corporation of N. J. Jersey City, N. J.
J. S. Doyle, Master Mechanic, Interborough Rapid Transit Co..New York, N. Y.
C. C. Lewis, Chief Engineer, Schenectady Railway Co.....Schenectady, N. Y.
W. H. McAloney, Superintendent of Shops, Denver City Tramway Co.Denver, Col.

Mr. Lewis having gone abroad and resigned as a member of the Executive Committee, his place was filled in February, 1905, by the appointment of

E. W. Olds, Superintendent of Rolling Stock, The Milwaukee Electric Railway and Light Co., Milwaukee, Wis.

Elected at St. Louis, Mo., October 11, 1904.

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President:

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Superintendent of Construction and Maintenance of Way, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

Second Vice-President:

J. S. DOYLE,

Superintendent of Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

Third Vice-President:

PAUL WINSOR,

Chief Engineer of Motive Power and Rolling Stock, Boston Elevated Railway Co., Boston, Mass.

Secretary and Treasurer:

S. W. MOWER,

General Manager, South-Western Traction Co., London, Ont.

EXECUTIVE COMMITTEE:

The Officers and

W. S. Twining, Chief Engineer, Philadelphia Rapid Transit Co..Philadelphia, Pa.
Fred N. Bushnell, Chief Engineer, The Rhode Island Co.....Providence, R. I.
W. Boardman Reed, Engineer Maintenance of Way, and Buildings, New York City Railway Co...New York, N. Y.
A. D. Campbell, Master Mechanic, Seattle Electric Co..... ....Seattle, Wash.

Mr. Reed having severed his connection with the New York City Railway Co., and resigned as a member of the Executive Committee, his place was filled, in August, 1906, by the appointment of

W. T. Dougan, Engineer Maintenance of Way and Buildings, New York City Railway Co..New York, N. Y.

Elected at Philadelphia, Pa., September 26, 1905.

OFFICERS, 1906–1907

President:

H. H. ADAMS,
Superintendent of Shops, The United Railways & Electric Co., Baltimore, Md.

First Vice-President:
FRED G. SIMMONS,
Superintendent of Construction and Maintenance of Way, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

Second Vice-President:
J. S. DOYLE,
Superintendent of Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

Third Vice-President:
PAUL WINSOR,
Chief Engineer of Motive Power and Rolling Stock, Boston Elevated Railway Co., Boston, Mass.

Secretary and Treasurer:
S. W. MOWER,
General Manager, South-Western Traction Co. London, Ont.

EXECUTIVE COMMITTEE:

The Officers and

*F. H. Lincoln, Assistant General Manager, Philadelphia Rapid Transit Co.....Philadelphia, Pa.
Fred N. Bushnell, Chief Engineer, The Rhode Island Co.....Providence, R. I.
W. T. Dougan, Engineer Maintenance of Way, New York City Railway Co....New York, N. Y.
H. B. Fleming, Chief Engineer, Chicago City Railway Co.....Chicago, Ill.
Elected at Columbus, Ohio, October 17, 1906.

OFFICERS, 1907–1908

President:

FRED G. SIMMONS,
Superintendent of Construction and Maintenance of Way, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

First Vice-President:
PAUL WINSOR,
Chief Engineer of Motive Power and Rolling Stock, Boston Elevated Railway Co., Boston, Mass.

Second Vice-President:
*F. H. LINCOLN,
Assistant General Manager, Philadelphia Rapid Transit Co., Philadelphia, Pa.

Third Vice-President:
W. H. EVANS,
Master Mechanic, International Railway Co., Buffalo, N. Y.

Secretary and Treasurer:
JOHN W. CORNING,
Electrical Engineer, Boston Elevated Railway Co., Boston, Mass.

EXECUTIVE COMMITTEE:

The Officers and

W. J. Harvie, Chief Engineer, Utica & Mohawk Valley Railway Co.....Utica, N. Y.
William Roberts, Superintendent of Motive Power, Northern Ohio Traction & Light Co., Akron, Ohio.
E. O. Ackerman, Engineer Maintenance of Way, Columbus Railway & Light Co., Columbus, Ohio.
John Z. Murphy, Electrical Engineer, Chicago Railways Co.....Chicago, Ill.
Elected at Atlantic City, N. J., October 16, 1907.

OFFICERS, 1908–1909

President:

PAUL WINSOR,
Chief Engineer of Motive Power and Rolling Stock, Boston Elevated Railway Co., Boston, Mass.

First Vice-President:
*F. H. LINCOLN,
Assistant General Manager, Philadelphia Rapid Transit Co., Philadelphia, Pa.

Second Vice-President:
W. H. EVANS,
Buffalo, N. Y.

Third Vice-President:
W. J. HARVIE,
Chief Engineer, Utica and Mohawk Valley Railway Co., Utica, N. Y.

Secretary-Treasurer:
JOHN W. CORNING,
Electrical Engineer, Boston Elevated Railway Co., Boston, Mass.

EXECUTIVE COMMITTEE:

The Officers and

William Roberts, Superintendent of Motive Power, Northern Ohio Traction & Light Co., Akron, Ohio.
E. O. Ackerman, Engineer Maintenance of Way, Columbus Railway & Light Co., Columbus, Ohio.
L. L. Smith, Master Mechanic, Chicago & Milwaukee Electric Railroad Co.....Highwood, Ill.
Martin Schreiber, Engineer Maintenance of Way, Public Service Railway Co., Newark, N. J.
Elected at Atlantic City N. J., October 16, 1908.

*Deceased.

OFFICERS, 1909-1910

President:

F. H. LINCOLN,*

Assistant-General Manager, Philadelphia Rapid Transit Co., Philadelphia, Pa.

First Vice-President (acting President):
W. J. HARVIE,
Chief Engineer, Syracuse Rapid Transit Railway Co., and Utica & Mohawk Valley Railway Co., Utica, N. Y.

Third Vice-President:
J. S. DOYLE,
Superintendent of Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

Second Vice-President:
E. O. ACKERMAN,
Engineer Maintenance of Way, Columbus Railway & Light Co., Columbus, Ohio.

Secretary-Treasurer:
JOHN W. CORNING,
Electrical Engineer, Boston Elevated Railway Co., Boston, Mass.

EXECUTIVE COMMITTEE:

The Officers and

Martin Schreiber, Engineer Maintenance of Way, Public Service Railway Co., Newark, N. J.
W. H. McAloney, Superintendent of Rolling Stock, The Denver City Tramway Co., Denver, Colo.
John Lindall, Superintendent of Rolling Stock and Shops, Boston Elevated Railway Co., Boston, Mass.
Thomas Elliott, Chief Engineer, Cincinnati Traction Co., Cincinnati, Ohio.

Elected at Denver, Colo., October 8, 1909.

OFFICERS, 1910-1911

(American Electric Railway Engineering Association.)

President:

W. J. HARVIE,

Chief Engineer, Syracuse Rapid Transit Railway Co., and Utica & Mohawk Valley Railway Co.

First Vice-President:
E. O. ACKERMAN,
Engineer Maintenance of Way, Columbus Railway & Light Co., Columbus, Ohio.

Third Vice-President.
MARTIN SCHREIBER,
Engineer Maintenance of Way, Public Service Railway Co., Newark, N. J.

Second Vice-President:
J. S. DOYLE,
Superintendent of Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

Secretary-Treasurer:
NORMAN LITCHFIELD,
Engineer Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

EXECUTIVE COMMITTEE:

The Officers and

John Lindall, Superintendent Rolling Stock and Shops, Boston Elevated Railway Co., Boston, Mass.
E. J. Burdick, Superintendent of Power, Detroit United Railway, Detroit, Mich.
G. H. Kelsay, Superintendent of Power, Indiana Union Traction Co., Anderson, Ind.
C. B. Voynow, Assistant Engineer of Way, Philadelphia Rapid Transit Co., Philadelphia, Pa.

Elected at Atlantic City, N. J., October 14, 1910.

*Deceased.

OFFICERS, 1911-1912

President:

E. O. ACKERMAN,

Engineer Maintenance of Way, Columbus Railway & Light Co., Columbus, Ohio

First Vice-President:
MARTIN SCHREIBER,
Engineer Maintenance of Way, Public Service Railway Co., Newark, N. J.

Second Vice-President:
L. P. CRECELIUS,
Electrical Engineer, The Cleveland Railway Co., Cleveland, Ohio.

Third Vice-President:
JOHN LINDALL,
Superintendent Rolling Stock and Shops, Boston Elevated Railway, Co., Boston, Mass.

Secretary-Treasurer:
NORMAN LITCHFIELD,
Engineer Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

EXECUTIVE COMMITTEE.

The Officers and

J. H. Hanna, Chief Engineer, The Capital Traction Co.....Wahington, D. C.
E. J. Burdick, Superintendent of Power, Detroit United Railway.....Detroit, Mich.
B. F. Wood, Assistant Engineer Motive Power Dept., Pennsylvana Railroad Co., Altoona, Pa.
H. A. Mullett, Superintendent of Rolling Stock, The Milwaukee Electric Railway & Light Co.....Milwaukee, Wis.

Elected at Atlantic City, N. J., October 13, 1911.

CONVENTION PROGRAM

(Chicago, Illinois, October 7, 8, 9, 10 and 11, 1912.)

Single Sessions

As in 1911 there are to be no afternoon sessions this year, except on Monday, and the large amount of work to come before the Convention will, therefore, require all meetings to be started promptly at the scheduled hour.

Inspection of Exhibits

Instead of giving up one entire day to the inspection of exhibits as in previous years, this year the afternoons of Tuesday, Wednesday, Thursday and Friday will be available for this purpose.

Announcement of Speakers' Names

Members taking part in the discussion are requested to announce their names in full before proceeding to speak in order that a proper record may be made by the stenographer.

MEETING ROOM

All regular and joint sessions in Brown Room, Saddle and Sirloin Club.

Monday, October 7th — 9.30 A. M. to 12.30 P. M.

Registration and Badges.

Monday, October 7th — 2.00 P. M. to 5.30 P. M.

Convention Called to Order.
Annual Address of President.
Annual Report of Executive Committee.
Annual Report of Secretary-Treasurer.
Appointment of Convention Committees.
Report of the Committee on Power Distribution.

Tuesday, October 8th — 9.30 A. M. to 11.00 A. M.

Report of the Committee on Block Signals.
Report of the Committee on Train Operation.
(Joint Session with Transportation and Traffic Association.)

Tuesday, October 8th — 2.00 P. M. to 5.00 P. M.

Inspection of Exhibits.

Wednesday, October 9th — 9.30 A. M. to 1.30 P. M.

Appointment of Committee on Nominations.
Report of the Committee on Buildings and Structures.
Report of the Committee on Standards.
Report of the Committee on Power Generation.

Wednesday, October 9th — 2.00 P. M. to 5.00 P. M.

Inspection of Exhibits.

Thursday, October 10th — 9.30 A. M. to 1.30 P. M.

Report of the Committee on Engineering Accounting.
Report of the Committee on Life of Railway Physical Property.

(Joint Session with Accountants' Association.)

Report of the Committee on Way Matters.

Thursday, October 10th — 2.00 P. M. to 5.00 P. M.

Inspection of Exhibits.

Friday, October 11th — 9.30 A. M. to 1.30 P. M.

Report of the Committee on Heavy Electric Traction.
Report of the Committee on Equipment.
General Business.
Report of the Committee on Nominations.
Election of Officers.
Installation of officers.
Adjournment.

Friday, October 11th — 2.00 P. M. *to* 5.00 P. M.

Inspection of Exhibits.

REGISTRATION AT THE 1912 CONVENTION

PAST PRESIDENTS OF THE ASSOCIATION

*H. H. Adams, with Ford, Bacon and Davis, New York, N. Y.

*F. G. Simmons, Superintendent of Public Works, City of Milwaukee, Wis.

*W. J. Harvie, President, Pottsville Union Traction Co., New York N. Y.

DELEGATES OF MEMBER COMPANIES

*Individual Member. *Note.*— Other Individual Members in attendance at the Convention of the Engineering Association (not delegates of member companies) are given in a separate list which follows the list of delegates of Member Companies.)

(§Indicates that the individual named is an officer and representative of more than one member company.)

Alabama City, Gadsden & Attalla Railway Co.:
Zell, Chas. J., Superintendent.

Altoona & Logan Valley Electric Railway Co.:
§Mulholland, W. J., Purchasing Agent.

Arkansas Valley Interurban Railway Co.:
*Bell, Chas. D., Chief Engineer and General Superintendent.

Aurora, Elgin & Chicago Railroad Co.:
Bowman, J. W., Master Mechanic.
Carlson, John, Roadmaster.
Chernich, A. B., Foreman Armature Department.
Doyle, E. P., Master Mechanic.
Doyle, F. A., Foreman.
Dunbar, W. E., Assisant Electrical Engineer.
Eggers, Henry, Line Foreman.
Faber, G. F., Superintendent of Construction.
Gould, E. F., Assistant to General Manager and Electrical Engineer.
Harvey, W. P., Purchasing Agent.
Herbert, W., Car Inspector.
Johnson, S. E., Chief Draughtsman.
Shafner, E. F., Line Foreman.
Sutherland, D., Chief Operating Engineer.
Thompson, F. B., Car Repairing Department.
Webster, A. L., Civil Engineer.

Delegates of Member Companies — (Continued).

BAY STATE STREET RAILWAY CO.:
*Holst, E. W., Superintendent of Equipment.
Palmer, G. W., Jr., Electrical Engineer.

BENTON HARBOR–ST. JOE RAILWAY & LIGHT CO.:
Logan, J. F., Master Mechanic.
Myers, C. C., Superintendent Overhead.

BIRMINGHAM RAILWAY, LIGHT & POWER CO.:
Daniels, T. R. H., Engineer.
Weld, F. M., Master Mechanic.

BOSTON ELEVATED RAILWAY CO.:
*Andrew, Jas. D., Superintendent of Power Stations.
*Whiting, S. E., Assistant to Sup't Rolling Stock and Shops.

BRIDGETON & MILLVILLE TRACTION CO.:
§Mulholland, W. J., Purchasing Agent.

BRITISH COLUMBIA ELECTRIC RAILWAY COMPANY, LTD.:
Dickie, G. A., Master Mechanic.
Hughes, Garnet B., Chief Engineer.
*Thompson, S. B., Mechanical Superintendent.

BROOKLYN RAPID TRANSIT SYSTEM:
*Crabbs, C. L., Engineer of Way and Structures.
*Gausman, S., Roadmaster Surface Lines, Department Way and Structures.
*Gove, Wm. G., Superintendent of Equipment.
Hilborn, H. H., Superintendent of Line and Electrical Engineering Department.
Roehl, C. E., Electrical Engineer.

CAPITAL TRACTION CO. (THE):
*Hanna, J. H., Chief Engineer.

CEDAR RAPIDS & IOWA CITY RAILWAY & LIGHT CO.:
Munson, Chas., Assistant Superintendent and Master Mechanic.

CHARLESTON CONSOLIDATED RAILWAY & LIGHTING CO.:
*Dawson, L. Y., Engineer.

CHARLOTTE ELECTRIC RAILWAY, LIGHT & POWER CO.:
Connell, W. R., Purchasing Agent.
Tyler, Edw. F., Supervising Engineer.

CHATTANOOGA RAILWAY & LIGHT CO.:
Stites, Richard, Engineer.

CHICAGO CITY RAILWAY CO.:
Alton, H., Shop Foreman.
Anderson, T. E., Mechanical Department.
Anderson, Edward, Assistant Foreman.
Anger, E. W., Superintendent of Shops.
Berg, C. P., Consulting Engineer.
Bergman, P. A., Assistant Foreman.
Boisbert, L. S., Engineering Department.

Delegates of Member Companies — (Continued).

CHICAGO CITY RAILWAY CO.:—(*Continued*)

Callaghan, M. J., Superintendent of Sub-Stations.
Carroll, Peter F., Assistant Timber Inspector.
Cohan, Wm., Foreman Repairs, Division 4.
Connors, J., Foreman Mechanical Department.
Crockett, M. S., Electric Car Worker.
Ditchie, J., Foreman Mechanical Department.
Drake, C. I., Accountant and Engineer.
Evans, G. C., Purchasing Agent.
Ferrarr, J. C., Foreman.
Fielding, J. J., Draftsman.
Freund, Charles H., Electrical Department.
Graves, W. F., Engineer Roadway.
Holmes, W. E., Draftsman Engineering Department.
Hunt, Frank, Chief Clerk, Purchasing Department.
Jaedtke, F. H., Draftsman.
Johnson, H. E., Shop.
Lentz, H. F., Way Master.
McCauley, T. H., Manager and Electrical Engineer.
McGill, Don, Superintendent of Shops.
Marsden, N. C., General Foreman.
Marteen, J., Foreman of Repair.
Mitchell, H. W., Engineer.
Mohrman, L. E., Foreman.
Murray, P. E., Electrical Department.
Page, H. D., Efficiency Work.
Peterson, F. K., Foreman.
Platte, C. S., Chief Lumber Inspector.
*Pratt, George W., Assistant Superintendent of Motive Power.
Riet, John G., General Foreman (Bonding).
Ripley, S. J., Assistant Engineer.
Rooks, E., Towerman.
Schmidt, Hugo, Chief Draftsman.
Stickley, A. J., General Yard Foreman.
Sullivan, M., Foreman Material Yard.
Thurlby, A. A., Superintendent of Wires and Cables.
Weatherwax, A. T., Electrician.
Wurth, Wm., Division Engineer.

CHICAGO & INTERURBAN TRACTION CO.:

Law, A. J., Roadmaster.
White, W. J., Purchasing Agent.
Young, E., Master Mechanic.

CHICAGO & JOLIET ELECTRIC RAILWAY CO.:

Ahrens, J. F., Electrician.
Bischman, August P., Assistant Master Mechanic

Delegates of Member Companies — (Continued).

CHICAGO & JOLIET ELECTRIC RAILWAY CO.: (*Continued*)

Bischman, L. A., Foreman.
Couch, L. A., General Repair.
Deiterick, C. N., Superintendent Overhead Lines.
Hawley, P. D., Foreman.
Ingold, B. C., Storekeeper.
LeRiche, George, Electrician.
§Mulholland, W. J., Purchasing Agent.
Patterson, C. S., Master Mechanic.
St. John, F. B., Foreman.
Tinnon, John B., Engineer Maintenance of Way.
Walker, Frank, Night Barn Foreman.

CHICAGO, LAKE SHORE & SOUTH BEND RAILWAY CO.:

Forsyth, J. A., Roadmaster.
Gray, Wm., Foreman.
Heslet, C. E., Master Mechanic.
Rolston, W. E., Superintendent of Power.
Wende, Richard, Superintendent of Overhead Lines.

CHICAGO & MILWAUKEE ELECTRIC RAILROAD CO.:

Huttleston, C., Electrical Engineer.
Hyatt, Jesse S., Engineer Maintenance of Way.
Morey, Chas. D., Engineering Department.
Nolan, H., Mechanical Department.
Osborn, J. W., Master Mechanic.
Pearson, Charles, Shop Foreman.
Pierce, R. E., Armature Winder.
Robinson, J. B., Electrician.

CHICAGO RAILWAYS CO.:

Abel, F., Foreman.
Amet, H. P., Assistant Engineer.
Anderson, Chas., Foreman Frog Shops.
Anderson, S. C., Foreman Car Shops.
Aitken, W. B., Station Superintendent.
Becker, W., Foreman Armature Winders.
Bloomberg, John, Chief Clerk Car Shops.
Bollinger, A., Repair Foreman.
Borg, F. G., Mechanical Engineer.
Boisacq, Chief Operator.
Bower, H. G., Map Department.
Bowman, J. S., Testing Engineer.
Brainerd, Al., Foreman Car Shops.
Breitenfeldt, R., Assistant Engineer.
Britton, M., Foreman.
Caul, Charles, General Roadmaster.
Caul, R. C., Field Engineer.

Delegates of Member Companies — (Continued).

CHICAGO RAILWAYS CO.:—(*Continued*)

Chamberlain, G., Repair Foreman.
Chambers, C., Assistant Roadmaster.
Cochran, L. L., Foreman.
Coughlan, J., Machine Inspector.
DeVielger, Edward, Foreman.
Donahue, T., Assistant Foreman Kedzie Avenue Station.
Downey, Joseph, Mason Foreman.
Duffy, P. J., Station Superintendent.
Elinger, Frank, Station Superintendent.
Emmert, R. W., Field Engineer Tunnels.
Emms, G., Assistant Station Superintendent.
Fay, B., Foreman Painters.
Felske, E., Foreman Electric Division.
Figg, W. H., Building Engineer.
Gecan, V., Foreman.
Gleason, John, Mechanical Engineer.
Goddard, W., Repair Foreman.
Goggin, Thos., Inspector.
Goodison, W. H., Inspector.
Gordon, C., Testing Engineer.
Grant, I. D., Grand Avenue Storeman.
Graves, F., Assistant Engineer.
Grunwald, Otto, Assistant Station Superintendent.
Hale, H. C., Repair Foreman, Car Shops.
Hamilton Charles, Station Superintendent.
Harrington, Michael, Station Superintendent.
Harris, J. W., Division Engineer.
Hays, R. L., Station Superintendent.
Horn, Henry, Operator.
Huff, H., Assistant Station Superintendent.
Hupp, Harry, Electrical Engineer.
Jerney, D. F., Assistant Station Superintendent.
Johnson, Andy, Foreman Track Department.
Johnson, Carl, Track Foreman.
Johnson, J. M., Station Superintendent.
Johnston, E., Assistant Roadmaster.
Jones, Wm., Assistant to Chief Engineer.
Karey, J., Track Foreman.
Kirschke, O., Assistant Foreman.
Koza, F. J., Engineer.
Kriet, Joseph, Assistant Station Superintendent.
Kroll, W. M., Superintendent Station.
Krueger, Wm., Foreman.
Langoht, O. F., Clerk.

Delegates of Member Companies — (Continued).

CHICAGO RAILWAYS CO.: (*Continued*)

Larson, C., Draftsman.
Lauer, Harry, Office Engineer.
LeBold, L. E., General Storekeeper.
Lee, E., Repair Foreman.
Lefever, F., Foreman.
Lewis, J., Repair Foreman.
Lindstrom, J., Foreman Carpenters.
Louer, M., Foreman Boilermakers.
McCabe, J., Plumber Foreman.
McCarthy, John, Operator.
McCauley, J. H., Outside Draftsman.
McDonald, Wm. D., Material Foreman.
McGuire, E. L., Station Superintendent.
McMahon, E. W., Electrician.
Mayo, Otto, Station Mechanic.
Meier, George, Foreman.
Miley, G. M., Electrical Engineer.
*Murphy, J. Z., Chief Engineer.
Murray, James J., Station Superintendent.
Newton, J. D., Foreman.
Patterson, R. M., Superintendent of Transmission.
Peterson, Frank, Electrician.
Phillips, L. R., Assistant Foreman.
Powers, Charles, Engineer.
Powers, J., Repair Foreman.
Prestly, P., Racine Avenue Storeman.
*Redderson, Arthur, Acting Superintendent of Car Shops.
Richter, H., Superintendent of Electrical Construction.
Ringstrom, C., Foreman.
Roberts, S. B., Assistant Station Superintendent.
Rochford, J. S., Assistant Station Superintendent.
Rogers, G. L., Operator.
Rogers, R. G., Mechanical Engineer.
Scully, P., Chief Construction Inspector.
Sigwalt, E. J., Assistant Storekeeper.
Smith, J., General Foreman.
Smith, Wm., Mechanical Foreman.
Swanson, B., Foreman.
Thelin, V. E., Engineer.
Thompson, Thomas, Foreman Coal Yards.
Thorssen, H. M., Purchasing Agent.
Vaillencourt, C. A., Electrical Engineer.
Vanderlike, A., Electrician.
Wallenborn, P. A., Foreman Track Department.

Delegates of Member Companies — (Continued).

CHICAGO RAILWAYS CO.:—(*Continued*)
Wells, W. C., Assistant Station Superintendent.
Westerman, E., Superintendent Conduit and Cable.
Wheeler, M. H., Assistant Chief Engineer.
Whelan, P., Repair Foreman.
Young, Frank D., Superintendent of Mechanical Department.

CHICAGO, SOUTH BEND & NORTHERN INDIANA RAILWAY CO.:
Andrus, L. B., Electrical Engineer.
Atkinson, C. E., Master Mechanic.
Coleman, David, Machinist.
Cornwell, R. E., General Storekeeper.
Emmons, S. Ewart, Assistant Engineer.
Hitchcock, W. A., Engineer.
Kuesport, F., Foreman Car Shops.
Miller, L. J., Superintendent of Sub-stations.
Southworth, D. C., Superintendent Overhead Lines.

CINCINNATI TRACTION CO.:
Burckmyer, C., Purchasing Agent.

CLEVELAND, PAINESVILLE & EASTERN RAILROAD CO.:
Aid, W. F., Engineer, Maintenance of Way.
Rider, L. J., Roadmaster.
Wood, P. J., Master Mechanic.

CLEVELAND RAILWAY CO. (THE):
Calaway, Chas. A., Track Foreman.
Calhoun, Chas. A., Track Foreman.
*Clark, C. H., Engineer, Maintenance of Way.
*Crecelius, L. P., Electrical Engineer.
O'Donnell, W. T., Mechanical Department.
*Scullin, Terrance, Master Mechanic.
Stanley, C. H., Purchasing Agent.

COLUMBUS RAILWAY & LIGHT CO.:
*Ackerman, E. O., Engineer Maintenance of Way.
Hott, Charles E., Master Mechanic.

CONNECTICUT CO. (THE):
*Miller, D. S., Electrical Engineer.

COUNTY TRACTION CO.:
French, J., Machinist.
Goss, G., Foreman.
Johnston, Wirt, Superintendent Overhead Construction.
McDonald, J. F., Draftsman.
Rekers, R., Electrician.
Scolen, A. J., Foreman.
Skibbee, A. C., Assistant Engineer.
Whitsell, J., Superintendent Equipment.
Wilson, W. L., Engineer, Maintenance of Way.

Delegates of Member Companies — (Continued).

DENVER CITY TRAMWAY CO. (THE):
*Dolezal, George, Shop Foreman.
Read, Norman, Electrical Engineer.
*Messner, John, Shop Foreman.

DETROIT UNITED RAILWAY:
Burlick, E. J., Superintendent of Power.
*Rifenberick, R. B., Consulting Engineer.
*Edwards, Allen F., Purchasing Agent.

EAST ST. LOUIS & SUBURBAN RAILWAY CO.:
Gaddis, E. M., Engineer.
*Merker, H. F., Engineer, Maintenance of Way.
*Parks, H. J., Master Mechanic.

EASTERN PENNSYLVANIA RAILWAYS CO.:
Calder, C. E., Purchasing Agent.

ELGIN & BELVIDERE ELECTRIC COMPANY:
Ager, F. A., Chief Engineer.

EL PASO ELECTRIC RAILWAY CO.:
Birney, C. O., Car Inspector.
*Lake, Edward N., Electrical Engineer.

ESCANABA TRACTION CO.:
Zuelke, Erwin, Chief and Electrical Engineer.

EVANSVILLE RAILWAYS CO.:
Crumley, T. R., Superintendent of Motive Power.

FONDA, JOHNSTOWN & GLOVESVILLE RAILROAD CO.:
*Sibbald, John, Master Mechanic.

FORT SMITH LIGHT & TRACTION CO.:
Chynoweth, G. W., Master Mechanic.

FORT WAYNE & NORTHERN INDIANA TRACTION CO.:
Brennan, J. J., Superintendent Maintenance of Way.
Burns, P. W., Assistant Purchasing Agent.
*Stevens, F. J., Master Mechanic.

FORT WAYNE & SPRINGFIELD RAILWAY CO.:
Brode, C. A., Master Mechanic.

FREDERICK RAILROAD CO.:
Coblentz, O. B., Chief Engineer.

GALVESTON ELECTRIC CO.:
Osborne, M. B., Master Mechanic.

GEORGIA RAILWAY & POWER CO.:
Chambers, J. T., Chief Engineer.
Moore, A. M., Master Mechanic.
*Smaw, W. H., Purchasing Agent.
Smith, C. A., Superintendent of Roadway.

GRAND RAPIDS, GRAND HAVEN & MUSKEGON RAILWAY CO.:
Morden, H. R., Foreman of Shop.
Rickerd, Byron, Roadmaster.

Delegates of Member Companies — (Continued).

GRAND RAPIDS, GRAND HAVEN & MUSKEGON RAILWAY CO.:—(*Continued*)
Sibert, C. A., Master Mechanic.
Weber, T. J., Engineer.

GRAND RAPIDS RAILWAY CO.:
*Livingston, W. E., Storekeeper.
Lynch, D., Master Mechanic.
Roderick, T. C., Chief Engineer.

HANOVER & MCSHERRYSTOWN STREET RAILWAY CO.:
Stokes, Leroy B., Master Mechanic.

HOUGHTON COUNTY TRACTION CO.:
Robinson, Philip I., Engineer.

HOUSTON ELECTRIC CO.:
Archibald, W. M., Engineer, Maintenance of Way.
Bennett, F. J., Master Mechanic.
Burnell, W. V., Superintendent of Construction.

HUDSON & MANHATTAN RAILROAD CO.:
*Hazelton, Hugh, Electrical Engineer.
*Hulme, J. W., General Foreman.
Klumpp, C. S., Assistant to General Superintendent and Engineer Maintenance of Way.

ILLINOIS TRACTION SYSTEM:
Bosenbury, J. M., Superintendent Motive Power Equipment.
Creviston, E. H., Chief Clerk to Superintendent of Motive Power.

BLOOMINGTON & NORMAL RAILWAY & LIGHT CO.:
Robinson, C. H., Master Mechanic.

CHICAGO, OTTAWA & PEORIA RAILWAY CO.:
Tucker, J. D., Operating Engineer.

DANVILLE STREET RAILWAY & LIGHT CO.:
Prior, O. F., Master Mechanic.

DECATUR RAILWAY & LIGHT CO.:
Peplow, M. L., Superintendent of Electricity.
Wood, C. H., Master Mechanic.

GALESBURG RAILWAY & LIGHT CO.:
Wharff, E. M., Operating Engineer.

PEORIA RAILWAY CO.:
Leech, A. F., Master Mechanic.
Palmblade, R., Engineer.

INDIANAPOLIS & CINCINNATI TRACTION CO.:
Skipton, George W., Master Mechanic.
Waggoner, S. G., Chief Engineer, Power Station.

INDIANAPOLIS TRACTION & TERMINAL CO.:
Anderson, Allen S., Assistant to Chief Engineer.
*Clark, L. M., Master Mechanic.
David, T. H., Assistant Engineer.
Haydon, E., Superintendent Overhead Construction.

Delegates of Member Companies — (Continued).

INDIANAPOLIS TRACTION & TERMINAL CO.:—(*Continued*)
McMath, Thos. B., Chief Engineer.
Tretton, James P., Assistant Superintendent.

INTERBOROUGH RAPID TRANSIT CO.:
*Doyle, J. S., Superintendent of Equipment.
*Litchfield, Norman, Engineer, Car Equipment.
*Pegram, George H., Chief Engineer.
*Waldron, J. M., Signal Engineer.

INTERURBAN RAILWAY & TERMINAL CO.:
Brueggemann, F. H., Master Mechanic.

IOWA CITY ELECTRIC RAILWAY CO.:
Goettsche, Edward, Master Mechanic.

JACKSONVILLE TRACTION CO.:
Bowman, A. B., Master Mechanic.

KANSAS CITY RAILWAY & LIGHT CO.:
Fritts, C. E., Electrical Engineer.
Harvey, A. E., Chief Engineer.
Queal, Ralph W., Assistant Electrical Engineer.
*Smith, G. J., Master Mechanic.
Stigall, E. E., Purchasing Agent.
Williams, Joseph, Traveling Inspector for Mechanical Department.

KANSAS CITY–WESTERN RAILWAY CO.:
Hull, J. W., Chief Electrician.

KENTUCKY TRACTION & TERMINAL CO.:
*Stuck, W. G., Master Mechanic.

KINGSTON, PORTSMOUTH & CATARAQUI ELECTRIC RAILWAY CO.:
Holder, John B., Foreman Carpenter.
*Oakes, A. E., General Foreman.

KNOXVILLE RAILWAY & LIGHT CO.:
Kington, J. M., Master Mechanic.
*Sawyer, W. H., Chief Engineer.

KOKOMO, MARION & WESTERN TRACTION CO.:
Hornung, J. C., Engineer.

LACKAWANNA & WYOMING VALLEY RAILROAD CO.:
Kimmett, Allen D., Master Mechanic.

LAKE SHORE ELECTRIC RAILWAY CO.:
Bragdon, Roy, Roadmaster.
Brown, A. V., Engineer.
Heckler, Fred, Superintendent of Motive Power.
Mann, J. O., Chief Lineman.
Moon, G. W., Chief Electrician.

LITTLE ROCK RAILWAY & ELECTRIC CO.:
*Koonce, A. R., Master Mechanic.

LOS ANGELES RAILWAY CORPORATION:
*Stephens, E. L., Master Mechanic.

Delegates of Member Companies — (Continued).

LOUISVILLE & SOUTHERN INDIANA TRACTION CO.:
Miller, F. H., Superintendent of Motive Power.

LYNCHBURG TRACTION & LIGHT CO.:
§Mulholland, W. J., Purchasing Agent.

MACON RAILWAY & LIGHT CO.:
Corbett, M. L., Superintendent of Construction.

MAHONING & SHENANGO RAILWAY & LIGHT CO.:
Lemmon, G. N., Chief Engineer.

MARYLAND ELECTRIC RAILWAYS (THE):
*Crouse, D. E., Engineer.

MASON CITY & CLEAR LAKE RAILROAD CO.:
Graham, F. M., Master Mechanic.
McPeak, B. Car barn Foreman.

MEMPHIS STREET RAILWAY CO.:
*Haylow, J. H., Engineer.
McWhorter, A. D., Master Mechanic.
Menter, B., Purchasing Agent.

MENOMINEE & MARINETTE LIGHT & TRACTION CO.:
Rocque, Joseph, General Foreman Street Railway Department.

METROPOLITAN WEST SIDE ELEVATED RAILWAY CO.:
Austin, Loring, Engineering Department.
Backus, N. A. Draftsman.
Barnhart, W. O., General Foreman Electrical Department.
Bell, G. R., General Foreman Sub-station.
Blair, E. J., Electrical Engineer.
Byrne, Edward J., Chief Clerk to Master Mechanic.
Daws, Adolph H., General Foreman Center Avenue Shop.
Fallon, B. J., Engineer Maintenance of Way.
Glenn, J. M., Electrical Engineer.
Grotke, Martin, Chief Clerk, Maintenance of Way Department.
Gustafson, C., Sub-station Operator.
Hanson, Chas. J., Foreman.
Hardin, H. L., Chief Operator and Engineer.
Harrison, Thomas, Chief Engineer.
Hydenblutt, G. G., Foreman Electrical Control Equipment.
*Johnson, H. A., Master Mechanic.
Jones, I. S., Signal Engineer.
Koch, Wm., Track Foreman.
Kawol, T. A. F., Chief Clerk Electrical Department.
Kretschmer, E. E., Purchasing Agent.
Lange, Chas., Switchtender.
Mabie, D. C., Assistant Chief Engineer.
Mock, C. M., Chief Engineer.
Otis, H. A., Draftsman.
Poggendorf, H. S., Foreman Machine Shop.

Delegates of Member Companies — (Continued).

METROPOLITAN WEST SIDE ELEVATED RAILWAY CO.—(*Continued*)

Rinehart, J., Sub-station Operator.
Rowek, B., General Foreman.
Shaw, C. E., Interlocking Foreman.
Sheehan, Daniel, General Roadmaster.
Stephenson, J. W., Engineer.
Tierney, R. J., Right-of-way Inspector.
Wade, R. N., Assistant Engineer Maintenance of Way.
White, H. N., Secretary to Master Mechanic.
Wolfersheim, John, Carpenter Foreman.

CHICAGO & OAK PARK ELEVATED RAILROAD CO.:

Krue, J. G., Mechanical Clerk.
McDonald, J. A., Roadmaster.
Sillers, A., General Foreman.

NORTHWESTERN ELEVATED RAILROAD CO.:

Bahr, Edward, Armature Foreman.
Bittourna, J. J., Assistant Purchasing Agent.
Borcher, W. J., Chief Clerk, Purchasing Department.
Conlen, W., General Foreman.
Cronin, F., Track Foreman.
Dane, George, Interlocking Foreman.
Gerber, A. N., Assistant Chief Engineer.
Elliott, F. P., Chief Operating Engineer.
Fenger, A. D., Clerk.
Howard, John, Draftsman.
Kassebaum, H., Draftsman.
Millet, J. D., Storekeeper.
Nickerson, B. F., Roadmaster.
O'Brien, John J., Air Brake Foreman.
Perkins, H., Assistant Engineer.
Polinsky, H., Carpenter.
Schaff, E., Foreman.
Trinkhaus, C. J., Interlocking Foreman.
Young, Herman, Foreman Electrical Department.

SOUTH SIDE ELEVATED RAILWAYS:

Ackerman, James, Foreman.
Bach, C., Electrician.
Barnham, W. A., Engineer.
Bartels, E., Electrician.
Bealand, G. T., Copper Foreman.
Bland, G., Carpenter Foreman.
Bonaker, George J., Towerman.
Bridges, M. W., Chief Clerk to Master Mechanic.
Clayton, T. M., Assistant Engineer.

Delegates of Member Companies — (Continued).

SOUTH SIDE ELEVATED RAILWAY CO.—(*Continued*)

Davies, L. S., Foreman Electrician.
Davis, W., Towerman.
Day, C., General Foreman.
Dean, R. H., Secretary and Purchasing Agent.
Dockstader, C. M., Electrical Inspector.
Edwards, Herman, Operator.
Forbes, P., Machine Foreman.
Gross, N. R., Assistant Engineer.
Hansen, Otto, Electrician.
Harding, Sidney, Electrician.
Jones, Chas. H., Assistant Electrical Engineer.
Keane, Timothy J., Clerk, Mechanical Department.
Kelly, John, Electrician.
Latham, H., Foreman.
Lovett, Frank, Towerman.
McMenamen, Ed., Foreman.
Matton, G. A., Interlocking Foreman.
Mitchell, F., Track Foreman.
Mitchell, Thomas, Traction Foreman.
Mulcahy, Thomas, Operator.
Nelson, W. H., Electrical Foreman.
Oleson, J. E., Chief Engineer.
Pardee, T., Engineer.
Reed, M. S., Electrician.
Schofield, J., Assistant Machinist.
Sheppard, F. E., Engineering Department.
Smith, D. L., Foreman.
Smith, Fred A., Foreman.
Swingen, James F., Electrical Foreman.

UNION CONSOLIDATED ELEVATED RAILWAY CO.:

Curtin, Andrew, Chief Engineer.
Hall, Edward G., Chief Electrician.
Wardrope, J., Night Operator

MICHIGAN UNITED TRACTION CO.:

Crowell, H. H., Engineer.
Foote, J. B., Engineer.
Sanderson, H. D., Chief Engineer.
Sherman, H. K., Purchasing Agent.

MILWAUKEE ELECTRIC RAILWAY & LIGHT CO.:

*Archambault, E. J., Civil Engineer.
*Austin, M. M., Assistant to Engineer Way and Structures.
*Benz, F. V., Purchasing Agent.
*Birkholz, H. E., Assistant Chief Draftsman.
*Boden, John, Carpenter.

Delegates of Member Companies—(Continued).

MILWAUKEE ELECTRIC RAILWAY & LIGHT CO.—(*Continued*).

Cahill, C. A., Chief Engineer Power Department.
Fay, John, Superintendent of Wires.
*Fitzpatrick, James C., Right-of-Way Agent.
*Flertzheim, H. A., Efficiency Engineer.
Grosskopf, J., Superintendent Buildings and Structures.
*Halvorsen, Hans, Foreman.
*Halvoss, H., Pattern Foreman.
Hinstoff, D. C., Assistant General Foreman.
*Hoehne, A. E., Foreman.
*Hunzicker, W. W., Engineer of Equipment.
Kennely, J. C., Foreman.
*Kleczka, George, Foreman.
*Lederer, Charles F. C., Roadmaster.
*Mullett, H. A., Superintendent of Rolling Stock.
*Naats, Gust., Foreman Electrical Repairs.
*Overholt, J. W., Chief Draftsman.
*Peterson, O. Smith, Draftsman.
*Peterson, Charles, Foreman.
*Pinkley, R. H., Engineer Way and Structures.
Witt, Louis, Engineer.

MILWAUKEE–WESTERN ELECTRIC RAILWAY CO.:

*Carson, Kit, Superintendent Right of Way and Franchise.

MINNEAPOLIS, ST. PAUL, ROCHESTER & DUBUQUE ELECTRIC TRACTION CO.:

Martin, F. A., Superintendent and Purchasing Agent.
O'Rourke, G. P., Superintendent of Motive Power.

MOBILE LIGHT & RAILROAD CO.:

*Coffin, S. M., Master Mechanic.

MONONGAHELA VALLEY TRACTION CO.:

Brennan, E., Superintendent Power and Machine Department.
Kingsland, R. L., Electrical Engineer.

MONTGOMERY TRACTION CO.:

Lee, John M., Superintendent of Tracks.

MONTREAL TRAMWAYS CO.:

Blair, D. E., Superintendent of Rolling Stock.
Byrd, A. S., Superintendent of Power Plant.
*Evans, Joseph D., Chief Engineer.

MUSKOGEE ELECTRIC TRACTION CO.:

Correy, A. G., Master Mechanic.

NEW ORLEANS RAILWAY & LIGHT CO.:

*Datz, L. C., Engineer of Roadway.

NEW YORK STATE RAILWAYS CO.:

Butler, H. M., Purchasing Agent.
*Cadle, C. L., Electrical Engineer.

Delegates of Member Companies — (Continued).

New York State Railways Co.—(*Continued*).
Cameron, G. M., Master Mechanic.
*Falconer, D. P., Engineer Maintenance Way.

Northern Illinois Light & Traction Co.:
Bedard, F. W., Engineer.

Northern Ohio Traction & Light Co.:
Douglass, Wm., Superintendent.
Lathrop, I. O., Construction Engineer.
*Roberts, W. H., Superintendent of Motive Power.
Ross, J. T., Chief Engineer.
Salber, W. E., Superintendent of Motive Power.

Ohio Electric Railway Co.:
Cochran, J. E., Superintendent of Lines and Stations.
Darnell, C. B., Roadway Engineer.
Thompson, Gaylord, Chief Engineer.

Ohio Valley Electric Railway Co.:
Fagan, J., Engineer.
Jones, H. W., Electrical Department.
Kuylenstjerne, A., Mechanical Engineer.
Schmidlapp, J. F., Master Mechanic.

Oklahoma Railway Co.:
Haskett, R. M., Engineer.

Omaha & Council Bluffs Street Railway Co.:
Wood, T. E., Master Mechanic.

Omaha, Lincoln & Beatrice Railway Co.:
Pinkerton, C. C., Master Mechanic.

Ottawa Electric Railway Co.:
Baldwin, R. A., Master Mechanic.

Pacific Electric Railway Co.:
Anderson, S. H., Electrical Engineer.
Small, Fred F., Mechanical Engineer.

Panama Tramways Co.:
Young, C. G., Consulting Engineer.

Parkersburg, Marietta & Interurban Railway Co.:
Gallaher, C. C., Chief Engineer.

Pennsylvania Railroad Co.:
Drayer, W. D., Draftsman.
Griffith, L. J., Foreman of Sub-stations and Transmission.
*Keiser, C. B., Master Mechanic of Manhattan Division.

Peoples Railway Co. (Dayton, Ohio):
§Mulholland, W. J., Purchasing Agent.
Towle, Joseph H., Master Mechanic.

Philadelphia Rapid Transit Co.:
*Senter, R. T., Superintendent of Rolling Stock and Buildings.

Delegates of Member Companies — (Continued).

PITTSBURGH RAILWAYS CO.:
Gowdy, H. K., Chief Engineer Power Stations.
*Larned, J. M., Engineer of Maintenance of Way.
*Pharo, H. A., Superintendent of Overhead Lines.
*Phillips, F. R., Superintendent of Equipment.
*Rogan, John A., Master Mechanic.
Uhlenhaut, F., Jr., Chief Engineer.
*Welsh, J. W., Electrical Engineer.

PUBLIC SERVICE RAILWAY CO.:
*Bedwell, C. F., Assistant Engineer of Maintenance of Way.
*Benedict, H. A., Mechanical Engineer.
*Connors, P. J., Superintendent of Shops.
*Dunne, E. J., Superintendent of Distribution.
*George, H. H., Assistant Engineer of Maintenance of Way.
*Haldeman, George H., Official Engineer.
*Knight, D. G., Superintendent of Buildings.
*Rosevear, M. B., Assistant Superintendent of Distribution.
*Schreiber, Martin, Engineer of Maintenance of Way.
*Single, J. L., Roadmaster.
*White, Martin, Superintendent of Maintenance of Way.

PUGET SOUND TRACTION, LIGHT & POWER CO.:
*Campbell, A. D., Superintendent of Rolling Stock and Shops.
Gaumnitz, E. C., Purchasing Agent.

QUINCY RAILWAY CO.:
Johnson, A., Master Mechanic.

RICHMOND LIGHT & RAILROAD CO.:
Brennan, T. F., Assistant Shop Foreman.

ROANOKE RAILWAY & ELECTRIC CO.:
§Mulholland, W. J., Purchasing Agent.

ROCKFORD & INTERURBAN RAILWAY CO.:
Hubbard, W. S., Chief Engineer.
*Jacques, L. W., Master Mechanic.
Swalm, F. M., Engineer Electrical Department.

ST. JOSEPH RAILWAY, LIGHT, HEAT & POWER CO.:
Henderson, Fred, Purchasing Agent.
Steffens, Fred, Master Mechanic.

SAN ANTONIO TRACTION CO.:
Rambo, A. V., Inspector.

SAN DIEGO ELECTRIC RAILWAY CO.:
*MacNutt, Homer, Superintendent of Motive Power.

SAN FRANCISCO–OAKLAND TERMINAL RAILWAYS CO.:
*Bell, H. P., Assistant Engineer.
*Brown, J. Q., Assistant to General Manager, Mechanical and Electrical Department.
*Kieffer, Stephen E., Director of Engineering.

Delegates of Member Companies — (Continued).

SCHENECTADY RAILWAY CO.:
*Doyle, F. J., Master Mechanic.
*Penoyer, D., Engineer of Maintenance of Way.

SCIOTO VALLEY TRACTION CO.:
Bailey, F. W. C., Electrical and Mechanical Engineer.

SCRANTON RAILWAY CO.:
Keen, C. G., Engineer.
§Mulholland, W. J., Purchasing Agent.

SHEBOYGAN RAILWAY & ELECTRIC CO.:
Curtis, J. L., Barn Foreman.
Fessenden, L. P., Chief Engineer.
Pagel, H. J., Master Mechanic.
Tousley, E. B., Electrician.
*Voth, W. B., Superintendent of Lighting and Power.

SIOUX CITY SERVICE CO.:
Feist, C. M,, Master Mechanic.

SOUTHERN WISCONSIN RAILWAY CO.:
Milbrook, Charles, Superintendent of Roadway.
Neff, William, Electrical Engineer.
*Stumpf, Mat., Master Mechanic.

SPRINGFIELD RAILWAY CO.:
Gunn, E. B., Master Mechanic.
§Mulholland, W. J., Purchasing Agent.

SYRACUSE, LAKE SHORE & NORTHERN RAILROAD CO.:
Metcalfe, A. B., Master Mechanic.

SYRACUSE RAPID TRANSIT RAILWAY CO.:
*Barnes, J. P., Chief Engineer.
*Roundey, E. P., Engineer Maintenance of Way.

TAMPA ELECTRIC CO.:
Folsom, T. C., Superintendent of Track.

TERRE HAUTE, INDIANAPOLIS & EASTERN TRACTION CO.:
Cook, W. W., Master Mechanic.
Hayes, L. W., Master Mechanic.
Schlesinger, A., Superintendent of Distribution, Sub-station.

TOLEDO, BOWLING GREEN & SOUTHERN TRACTION CO.:
Karns, A., Master Mechanic.

TOLEDO & CHICAGO INTERURBAN RAILWAY CO. (THE):
Hauff, Jack, Master Mechanic.
Ogden, M. J., Chief Engineer.
Vollick, E. L., Superintendent of Way.

TOLEDO RAILWAYS & LIGHT CO.:
Brown, C. A., Master Mechanic.
Munz, Chas. T., Purchasing Agent.

TOPEKA RAILWAY CO. (THE):
Morrison, W. R., Engineer.

Delegates of Member Companies — (Continued).

TORONTO RAILWAY CO.:
McCabe, P., Inspector of Air and Car House Equipment.
McRae, W. R., Master Mechanic.
Powers, M., Engineering Department.
Smith, James G., Engineering Department.
Wilson, Chas. L., Assistant Engineer.

TWIN CITY RAPID TRANSIT CO.:
Wilson, George L., Engineer Maintenance of Way.

UNION TRACTION COMPANY OF INDIANA:
Dunbar, S. R., Purchasing Agent.
Hemming, R. N., Superintendent of Motive Power.
*Kelsay, G. H., Superintendent of Power.
Mitchell, Louis A., Superintendent of Roadway.
Soulen, S. K., Master Mechanic.

UNITED RAILROADS OF SAN FRANCISCO:
*Bivins, W. T., Chief Engineer, Electrical Department.
Finnigan, Thomas, Purchasing Agent.
*Yount, J. M., Master Mechanic.

UNITED RAILWAYS & ELECTRIC COMPANY OF BALTIMORE:
*Staub, Wm. H., Purchasing Agent.

UNITED RAILWAYS COMPANY OF ST. LOUIS:
Byrgess, J. E., Superintendent of Wires and Cables.
Finn, Wm., Roadmaster.
Hawkins, C. L., Chief Engineer of Track Department.
Hobein, Charles A., Superintendent of Power Station.
O'Brien, M., Master Mechanic.

UTAH LIGHT & RAILWAY CO.:
Dagron, L. L., Engineer.
*Franklin, E. E., Master Mechanic.

UTICA & MOHAWK VALLEY RAILWAY CO.:
*Barnes, J. P., Chief Engineer.
*French, M. J., Engineer Maintenance of Way.
*Honold, P. J., Purchasing Agent.

VIRGINIA RAILWAY & POWER CO.:
Ely, E. S., Chief Engineer, Norfolk Division.

WARREN & JAMESTOWN STREET RAILWAY CO.:
Armstrong, Sam., Master Mechanic.

WASHINGTON RAILWAY & ELECTRIC CO.:
*Kimball, C. S., Engineer of Way.

WASHINGTON-VIRGINIA RAILWAY CO.:
Stephens, J. H., Engineer.

WATERLOO, CEDAR FALLS & NORTHERN RAILWAY CO.:
Lamb, W. G., Master Mechanic.
Mills, G. A., Electrical Engineer.
Rust, T. E., Chief Engineer.
Woodring, A. I., Superintendent Overhead Lines.

Delegates of Member Companies — (Continued).

WESTERN NEW YORK & PENNSYLVANIA TRACTION CO.:
*Page, Wilson K., Electrical Engineer.

WEST PENN RAILWAYS CO.:
*Durie, D., Master Mechanic.
Rogers, W. M., Superintendent of Line Construction.

WHEELING TRACTION CO.:
*O'Brien, Frank, Master Mechanic.
*Underwood, W. A., Superintendent of Maintenance of Way.

WILKES-BARRE RAILWAYS CO.:
Hoffman, E. A., Engineer Maintenance of Way.
Mann, J. K., Electrical Engineer.
Mullery, Charles E., Inspector.
Reese, E. F., Motor Truck Department.
Wheaton, Wm. H., Master Mechanic.

WILLIAMSPORT PASSENGER RAILWAY CO.:
*Colton, H. M., Supervisor of Track.
*Easty, C. B., Master Mechanic.

WINDSOR, ESSEX & LAKE SHORE RAPID RAILWAY CO.:
Chisholm, W. W., Chief Engineer.

WINNIPEG ELECTRIC RAILWAY CO.:
Garrett, George, Master Mechanic.

WISCONSIN PUBLIC SERVICE CO.:
Phenecie, C. P., Electrical Engineer and Superintendent.

MEMBERS (INDIVIDUAL) IN ATTENDANCE.

EDITOR'S NOTE.— The names of other members (individual) in attendance at the Convention are given in the list of Delegates of Member Companies and are there designated by means of an asterisk (*).

Aberdeen, H. Lizars, Railway Roller Bearing Co., Syracuse, N. Y.
Ackerson, D. H., Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.
Adam, R. S., The G. Drouve Co., Chicago, Ill.
Adams, H. H., with Ford, Bacon & Davis, New York, N. Y.
Addison, Dr. T. A., General Electric Co., San Francisco, Cal.
Adreon, E. L., Westinghouse Traction Brake Co., St. Louis, Mo.
Aertsen, G., The Midvale Steel Co., Philadelphia, Pa.
Aikman, B. S., National Brake & Electric Co., Milwaukee, Wis.
Alden, Charles A., Street Railway Engineer, Pennsylvania Steel Co., Steelton, Pa.
Aldrich, William, Goldschmidt Thermit Co., 90 West Street, New York, N. Y.
Alexander, J. H., Engineer to City Street Railroad Commission, Cleveland, Ohio.
Alexander, T. P., Westinghouse Elec. & Mfg. Co., Boston, Mass.
Allen, E. W., General Electric Co., Chicago, Ill.
Allen, G. F., Railway Materials Co., Chicago, Ill.
Allen, J. Drew, Chicago Sales Office, Maryland Steel Co. and Pennsylvania Steel Co., Chicago, Ill.
Allen, Walter H., Pennsylvania Steel Co., Steelton, Pa.
Alpern, M., American Engineering Co., Philadelphia, Pa.
Alt, Walter, St. Louis Car Co., St. Louis, Mo.
Anderson, A. C., Chicago Pneumatic Tool Co., Chicago, Ill.
Anderson, A. M., Chicago Pneumatic Tool Co., Chicago, Ill.
Anderson, C. O., Anderson Brake Adjuster Co., Omaha, Neb.
Andrews, R. L., Glidden Varnish Co., Cleveland, Ohio.
Archbold, W. K., President, Archbold–Brady Co., Syracuse, N. Y.
Archibald, F. B., National Lock Washer Co., Newark, N. J.
Arlein, E. J., W. H. Coe Mfg. Co., Chicago, Ill.
Arlin, A. W., Salesman, General Electric Co., Delta Building, Los Angeles, Cal.
Armbrust, C. W., Love Brake Shoe Co., Chicago, Ill.
Armstrong, W. A., Electric Service Supplies Co., Philadelphia, Pa.
Arnold, C. N., Minerallac Electric Co., Chicago, Ill.
Arnold, George, Cleveland Frog & Crossing Co., Cleveland, Ohio.
Arnold, Geo. J., American Surety Co., New York, N. Y.

Members (Individual) in Attendance—(Continued).

Arthur, H. G., Niles Car & Manufacturing Co., Cleveland, Ohio.
Ashhurst, L. R., Jr., Manager, Street Railway Department, Wm. Wharton, Jr., & Co., Philadelphia, Pa.
Athen, George C., National Brake & Electric Co., Milwaukee, Wis.
Atkin, G. H., Electric Storage Battery, Chicago, Ill.
Atkin, W. Y., American Electrical Works, Chicago, Ill.
Atkins, James, Jr., American Association of Creosoted Wood Paving Manufacturers, Chicago, Ill.
Atwater, Fred, Treasurer, Columbia Nut & Bolt Co., Bridgeport, Conn.
Augustus, J. D., Chatham Electric Switching Device Co., Louisville, Ky.
Austin, W. A., Anderson Brake Adjuster Co., Omaha, Neb.
Babtiste, C. A., *Electric Railway Journal,* New York, N. Y.
Baker, C. M., Murphy Varnish Co., Chicago, Ill.
Baker, E. H., Vice-President, Galena Signal Oil Co., 26 Broadway, New York, N. Y.
Baker, Merrill G., Cambria Steel Co., Johnstown, Pa.
Baker, R. N., General Electric Co., Chicago, Ill.
Bales, J. E., Lyon Metallic Manufacturing Co., Aurora, Ill.
Banks, Carl C., Maryland Steel Co. and Pennsylvania Steel Co., San Francisco, Cal.
Barden, G. A., Chicago Pneumatic Tool Co., Chicago, Ill.
Barker, J. K., Jones & Laughlin Steel Co., Pittsburgh, Pa.
Barr, James C., The Rail Joint Co., Boston, Mass.
Barron, A. E., Templeton-Kenly Co., Chicago, Ill.
Barrows, Allan S., Pantasote Company, Chicago, Ill.
Barry, C. E., Railway Department, General Electric Co., Schenectady, N. Y.
Barry, J. G., Manager Railway Department, General Electric Co., Schenectady, N. Y.
Bartholomew, W. S., District Manager, Westinghouse Traction Brake Co., 1545 Railway Exchange Building, Chicago, Ill.
Barton, B. S., The G. Drouve Co., Chicago, Ill.
Batt, W. L., Hess-Bright Manufacturing Co., Philadelphia, Pa.
Baur, H. J., Johnson Coin Counting Machine Co., Chicago, Ill.
Baxter, F. L., General Electric Co., Harrison, N. J.
Bayler, A. H., General Electric Co., New York, N. Y.
Baylies, F. N., Aluminum Company of America, Chicago, Ill.
Beaser, William, Jr., Treasurer, The Whitmore Manufacturing Co., Cleveland, Ohio.
Beam, E. E., Cleveland Trolley Wheel Co., Cleveland, Ohio.
Beard, W. K., *Electrical Railway Journal,* Chicago, Ill.
Beatty, E. G., Galena Signal Oil Co., Franklin, Pa.
Beattys, W. H., Jr., National Brake & Electric Co., Chicago, Ill.

Members (Individual) in Attendance—(Continued).

Beck, C. C., Ohio Brass Co., Mansfield, Ohio.
Beck, C. H., Westinghouse Traction Brake Co., Pittsburgh, Pa.
Beggs, John I., St. Louis Car Co., St. Louis, Mo.
Begstrup, Ed., Goldschmidt Thermit Co., New York, N. Y.
Belknap, R. E., Sales Agent, The Pennsylvania Steel Co., Western Union Building, Chicago, Ill.
Bell, Charles H., Mica Insulator Co., New York, N. Y.
Bell, Geo., The Esterline Co., Lafayette, Ind.
Bendelari, F. N., President, The Acme Indicator Co., Cleveland, Ohio.
Benedict, J. T., Boss Nut Co., Chicago, Ill.
Bennett, William A., Griffin Wheel Co., Chicago, Ill.
Benson, Fred T., General Electric Co., Chicago, Ill.
Bentley, W. H., Standard Steel Works, Chicago, Ill.
Berg, Max A., Secretary, Electric Service Supplies Co., Chicago, Ill.
Berger, E. F., The Midvale Steel Co., Chicago, Ill.
Berry, Bertram, Manager Sales, Heywood Brothers & Wakefield Co., 516 West 34th Street, New York, N. Y.
Berry, W. E., Carnegie Steel Co., 30 Church Street, New York, N. Y.
Besuden, Edwin, The Jewett Car Co., Newark, Ohio.
Bibbins, J. R., Resident Engineer, B. J. Arnold Co., San Francisco, Cal.
Biddison, C. T., McGuire Cummings Manufacturing Co., Chicago, Ill.
Bigelow, Geo. S., Chicago Varnish Co., Chicago, Ill.
Billau, H. E., The Sherwin-Williams Co., Cleveland, Ohio.
Billings, C. P., National Brake & Electric Co., Milwaukee, Wis.
Birdsell, C. H., President, Johnson Coin Counting Machine Co., Chicago, Ill.
Bischoff, W. E., Western Electric Co., Chicago, Ill.
Bisel, W. M., National Brake & Electric Co., Milwaukee, Wis.
Bishop, T. M., Consolidated Car Heating Co., Chicago, Ill.
Black, J. S., Salesman, The Eureka Co., North East, Pa.
Blake, H. W., Editor, *Electric Railway Journal*, New York, N. Y.
Blakeslee, R. B., Superintendent, Du Bois Traction Co., Du Bois, Pa.
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Hale, A. A., Griffin Wheel Co., Boston, Mass.

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Hamer, W. D., Electric Service Supplies Co., Chicago, Ill.
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Harper, R. H., 129 North 16th Street, East Orange, N. J.
Harrah, Ernest, The Midvale Steel Co., Philadelphia, Pa.
Harrington, W. E., Keystone Lubricating Co., Philadelphia, Pa.
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Hegeman, Harold A., Salesman, U. S. Metal & Manufacturing Co., 165 Broadway, New York, N. Y.

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Henderson, Wm. M., Pennsylvania Steel Co., Harrisburg, Pa.

Henkle, Thos. H., Electric Service Supplies Co., Chicago, Ill.

Henly, C. A., *Electric Railway Journal,* New York, N. Y.

Hennessy, J. F., Chicago Sales Office, Pennsylvania Steel Co., Maryland Steel Co., Chicago, Ill.

Hertzog, R. R., The Whitmore Manufacturing Co., Chicago, Ill.

Heulings, W. H., Jr., Assistant Secretary, The J. G. Brill Co., Philadelphia, Pa.

Hiatt, H. I., The National Malleable Castings Co., Chicago, Ill.

Hickey, F. S., Dearborn Drug & Chemical Co., Chicago, Ill.

High, J. M., Manager of Sales Department, Pantasote Co., 11 Broadway, New York, N. Y.

Hill, G. H., Assistant Engineer of Railway and Track Department, General Electric Co., Schenectady, N. Y.

Hill, John T., Vice-President, R. C. Hoffman & Co., Inc., Pennsylvania Steel Co., Maryland Steel Co., Baltimore, Md.

Hills, A. F., The Crouse Hinds Co., Syracuse. N. Y.

Hincher, W. W., A. & J. M. Anderson Manufacturing Co., Chicago, Ill.

Hinds, P. A., Ohio Brass Co., Toronto, Ont., Can.

Hinmon, W. E., Peter Smith Heater Co., Detroit, Mich.

Hirtzel, O. C., North East, Pa.

Hodgkins, R. T., Yale & Towne, Chicago, Ill.

Hoffman, J. K., Hale & Kilburn Co., Chicago, Ill.

Hoge, James B., Automatic Signal & Appliance Co., Cleveland, Ohio.

Holcomb, J. Roger, The Midvale Steel Co., Philadelphia, Pa.

Hollingsworth, Geo. H., Consolidated Car Fender Co., Providence, R. I.

Hollis, Joseph, Trolley Supply Co., Canton, Ohio.

Holloway, H. C., The Rail Joint Co., Chicago, Ill.

Holmes, W., Galena Signal Oil Co., Cincinnati, Ohio.

Holy, G. H., Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.

Hovey, M. H., Signal Engineer, Wisconsin Railroad Commission, Madison, Wis.

Hovey, W. G., The Okonite Co., New York, N. Y.

Howard, J. C., Superintendent, The Eureka Co., North East, Pa.

Howatt, Gerald, The Electric Railway Improvement Co., Cleveland, Ohio.

Members (Individual) in Attendance — (Continued).

Howe, W. K., Chief Engineer, General Railway Signal Co., Rochester, N. Y.
Howry, John, Standard Underground Cable Co., Pittsburgh, Pa.
Huber, Wm. E., The Electric Railway Improvement Co., Cleveland, Ohio.
Humes, W. S., Transportation Utilities Co., Chicago, Ill.
Humphrey, A. L., Vice-President and General Manager, Westinghouse Air Brake Co., Pittsburgh, Pa.
Hunt, E. J., *Electric Railway Journal,* Chicago, Ill.
Hunt, Wm. M., Green Engineering Co., Chicago, Ill.
Hunt, W. P., The Buda Co., Chicago, Ill.
Hunter, D., Jr., The Under Feed Stoker Co. of America, Chicago, Ill.
Hunter, Lytle J., Hunter Illuminated Car Sign Co., Flushing, N. Y.
Hunter, R. W., Poole Bros., Chicago, Ill.
Huppertz, George C., National Brake & Electric Co., Milwaukee, Wis.
Hutchins, S. D., Westinghouse Traction Brake Co., Columbus, Ohio.
Hutchinson, R. P., Carnegie Steel Co., Cleveland, Ohio.
Hyman, Edgar H., General Manager, Electric Package Agency, Cleveland, Ohio.
Iddimgs, Roscoe G., Pyrene Company, Dayton, Ohio.
Illingworth, T. W., The Midvale Steel Co., Philadelphia, Pa.
Ingham, W. B., Inspector of Traffic, Public Utilities Commission, 738 Broad Street, Newark, N. J.
Ingram, A. B., Vice-Chairman, Ontario Railway and Municipal Board, Toronto, Ontario, Can.
Inwood, Harry A., The Standard Paint Co., New York, N. Y.
Ives, C. A., Salesman, General Electric Co., Chicago, Ill.
Jackson, D. C. and W. B., Consulting Engineers, Harris Trust Building, Chicago, Ill.
Jackson, Walter, Associate Editor, *Electric Railway Journal,* 239 West 39th Street, New York, N. Y.
Jameson, F. H., Electric Service Supplies Co., Chicago, Ill.
Jay, J. C., Jr., Agent, The Pennsylvania Steel Co., 71 Broadway, New York, N. Y.
Jeandron, W. J., 172 Fulton Street, New York, N. Y.
Jellinek, Marcell, Budapest Local Railways, Budapest, Hungary.
Jenks, A. P., General Electric Co., Chicago, Ill.
Johann, H. A., Wm. Wharton, Jr., & Co., Inc., Philadelphia, Pa.
Johnson, B. A., American Brake Shoe & Foundry Co., Chicago, Ill.
Johnson, A. L., Electric Railway Equipment Co., Cincinnati, Ohio.
Johnson, C. F., Wason Manufacturing Co., Springfield, Mass.
Johnson, E. A., The Duff Manufacturing Co., Pittsburgh, Pa.
Johnson, F. E., Ohio Brass Co., Chicago, Ill.
Johnson, H. H., Electric Service Supplies Co., Chicago, Ill.
Johnson, J. M., Johnson Coin Counting Machine Co., Chicago, Ill.
Johnson, Oscar, Scientific Railway Appliances, Chicago, Ill.

Members (Individual) in Attendance — (Continued).

Johnson, O. P., Star Brass Works, Kalamazoo, Mich.
Johnston, C. L., The National Malleable Castings Co., Toledo, Ohio.
Johnstone, H. C., Representative, Midvale Steel Co., 841 Railway Exchange, Chicago, Ill.
Jones, C. L., Vice-President, The Falk Co., Milwaukee, Wis.
Jones, Frank, Cincinnati Car Co., Cincinnati, Ohio.
Jones, W. F., National Tube Co., Pittsburg, Pa.
Junkersfeld, Peter, Assistant Second Vice-President, Commonwealth Edison Co., Chicago, Ill.
Kadish, R. B., New Tone System Co., Chicago, Ill.
Kaiser, D. L., Westinghouse Electric & Manufacturing Co., St. Louis, Mo.
Kamps, S. L., T. H. Symington Co., Rochester, N. Y.
Kathe, F. D., National Carbon Co., Cleveland, Ohio.
Kavanaugh, Joseph, Wm. Wharton, Jr., & Co., Inc., Philadelphia, Pa.
Kayler, W. G., Westinghouse Traction Brake Co., New York, N. Y.
Kearney, James R., Western Electric Co., New York, N. Y.
Keegan, Harry F., Tool Steel Gear & Pinion Co., Chicago, Ill.
Keese, S. J., Manager, Los Angeles Office, Westinghouse Electric & Manufacturing Co., Los Angeles, Cal.
Keily, W. E., McGraw Publishing Co., Chicago, Ill.
Kelker, R. F., Jr., Board of Supervising Engineers, 105 South La Salle Street, Chicago, Ill.
Kelly, Thomas F., American Electrical Works, Phillipsdale, R. I.
Kenfield, H. J., President, Kenfield-Fairchild Pub. Co., 431 South Dearborn Street, Chicago, Ill.
Kennedy, F. B., Recording Register & Fare Box Co., New Haven, Conn.
Kenney, E. F., Cambria Steel Co., Johnstown, Pa.
Kent, Jas. D., Electrical Engineer, Union Railway Co., New York, N. Y.
Kerschner, R. M., Union Electric Co., Pittsburgh, Pa.
Kerwin, James J., Kerwin Machine Co., Detroit, Mich.
Ketteman, C. W., Ohmer Fare Register Co., Dayton, Ohio.
Keyes, C. B., Engineer, General Electric Co., 30 Church Street, New York, N. Y.
Kiek, J. A., Western Electric Co., Chicago, Ill.
Killion, F. D., Western Electric Co., New York, N. Y.
King, Alvin S., Eastern Manager, The Sterling Varnish Co., Edgeworth, Pa.
King, C. R., Pittsburgh Steel Co., Pittsburgh, Pa.
King, Henry C., American Mason Safety Tread Co., Chicago, Ill.
Kingsley, F., *Electric Railway Journal*, New York, N. Y.
Kingston, W. W., Lorain Steel Co., Atlanta, Ga.
Kippenberger, Geo. L., St. Louis Car Co., St. Louis, Mo.

Members (Individual) in Attendance — (Continued).

Kirby, L. J., Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Kirker, G. B., Westinghouse Electric & Manufacturing Co., San Francisco, Cal.
Kirschke, M. T., Jr., McGuire-Cummings Manufacturing Co., Chicago, Ill.
Kitchen, F. T., Gold Car Heating & Lighting Co., New York, N. Y.
Kittsley, Frank, Master Mechanic, Milwaukee Northern Railway Co., Cedarburg, Wis.
Kittle, E. B., Vice-President, Vacuum Car Ventilating Co., Chicago, Ill.
Kleinschmidt, H. F. A., Lorain Steel Co., Johnsown, Pa.
Klineschmidt, R. J., Yale & Towne Manufacturing Co., Chicago, Ill.
Knickerbocker, C. K., Sales Agent, Griffin Wheel Co., 600 Western Union Building, Chicago, Ill.
Knight, C. S., Jr., American Steel & Wire Co., Chicago, Ill.
Koch, Gus, St. Louis Car Co., St. Louis, Mo.
Koch, Otto, Corliss Carbon Co., Bradford, Pa.
Koury, C. M., C. M. Koury Co., Atlantic City, N. J.
Kroener, G. A., Ohio Brass Co., Pittsburgh, Pa.
Kucera, J. A., Business Manager, *Electric Railway Journal*, 239 West 39th Street, New York, N. Y.
Kulicke, F. W., Engineer, Nachod Signal Co., Philadelphia, Pa.
Kuhn, H. J., Flood & Conklin Co., Newark, N. J.
Lake, W. A., The Pantasote Co., 11 Broadway, New York, N. Y.
Lambert, M. B., Railway Equipment Division, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Lamme, B. G., Chief Engineer, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Landreth, J. P., Garlock Packing Co., Chicago, Ill.
Lane, R. G., American Electrical Works, Phillipsdale, R. I.
Lang, E. C., Heywood Brothers & Wakefield Co., Chicago, Ill.
Lange, Felix, Goldschmidt-Thermit Co., 90 West Street, New York, N. Y.
Lange, H. O., Ferguson Lange Foundry Co., Chicago, Ill.
Langford, F. W., Universal Safety Tread Co., Boston, Mass.
Latey, H. N., Railway Department, General Electric Co., 30 Church Street, New York, N. Y.
Layng, J. F., General Electric Co., Schenectady, N. Y.
Lawrence, F. W., Engineer, Electrical Securities Corporation, 62 Cedar Street, New York, N. Y.
Lawyer, W. H., The Whitmore Mfg. Co., Cleveland, Ohio.
Leake, G. F., Westinghouse Electric & Manufacturing Co., Memphis, Tenn.
Leake, R. C., General Railway Signal Co., Rochester, N. Y.

Members (Individual) in Attendance — (Continued).

Le Beau, E. A., Chicago Railway Equipment Co., Chicago, Ill.
Lee, R. W. H., Representative, Galena-Signal Oil Co., 411 Traction Building, Indianapolis, Ind.
Lee, Wallace R., Baldwin Locomotive Works, 500 North Broad Street, Philadelphia, Pa.
Leeds, E. L., Mechanical Engineer and Salesman, Niles-Bement-Pond Co., 111 Broadway, New York, N. Y.
Leet, C. N., National Brake & Electric Co., Milwaukee, Wis.
LeGrand, Nic., St. Louis Car Co., St. Louis, Mo.
Leibold, C. P., The Ohio Brass Co., Mansfield, Ohio.
Leidenger, Joseph, Eastern Sales Manager, The Dayton Manufacturing Co., Dayton, Ohio.
Leidenger, P., Western Sales Manager, The Dayton Manufacturing Co., Dayton, Ohio.
Levings, A. D., Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Lewis, E., W. R. Garton Co., Chicago, Ill.
Lewis, E. S., Pittsburgh Steel Co., Pittsburgh, Pa.
Lewis, H. G., Electric Service Supplies Co., Philadelphia, Pa.
Lewis, W. A., The J. G. Brill Co., Philadelphia, Pa.
Libkeman, William A., Sales Agent, Standard Motor Truck Co., Fisher Building, Chicago, Ill.
Liddell, R. B., The J. G. Brill Co., Philadelphia, Pa.
Lindgren, Carl O., Rand McNalley & Co., Chicago, Ill.
Lintern, Wm., The Holland Trolley Supply Co., Cleveland, Ohio.
Lippincott, H. S., American Bitumastic Enamel Co., Cleveland, Ohio.
Littlefield, Arthur S., Lorain Steel Co., Chicago, Ill.
Littlefield, A. S., President, North American Railway Construction Co., Chicago, Ill.
Livsey, J. H., Manager, General Electric Co., 1410 Majestic Building, Detroit, Mich.
Lotz, Alfred, The Under Feed Stoker Co. of America, Chicago, Ill.
Lounsbury, Charles, American Railway Supply Co., New York, N. Y.
Lubersky, I., Hale & Kilburn Co., Chicago, Ill.
Lyman, F. D., Electric Service Supplies Co., Montreal, Que.
Lyman, Wm., Lorain Steel Co., Johnstown, Pa.
Lynn, T. E., Salesman, The Eureka Co., North East, Pa.
Lyon, Chas., Engineer, Speer Carbon Co., St. Mary's, Pa.
Lysons, J. W., Western Automatic Fender Co., Seattle, Wash.
McAdams, S. L., Cleveland Trolley Wheel Co., Cleveland, Ohio.
McAlarney, J. A., Carnegie Steel Co., New York, N. Y.
McAloney, N. J., Emery Pneumatic Lubricator Co., St. Louis, Mo.
McCabe, H. P., J. J. McCabe, New York, N. Y.
McClellen, B. S., McCord Manufacturing Co., Chicago, Ill.

Members (Individual) in Attendance — (Continued).

McConnaughy, H. G., Dearborn Drug & Chemical Works, 299 Broadway, New York, N. Y.
McCormick, C., American Car & Foundry Co., Chicago, Ill.
McCready, H., The Union Switch & Signal Co., Swissvale, Pa.
McDonald, H. H., Lorain Steel Co., Chicago, Ill.
McDonald, R. J., Field Engineer, Board of Supervising Engineers, Chicago, Ill.
McDonald, W. D., Branch Manager, Westinghouse Electric Manufacturing Co., Minneapolis, Minn.
McDowell, W. J., General Vehicle Co., Chicago, Ill.
MacDuffie, R. L., Vice-President, Wendell & MacDuffie Co., New York, N. Y.
McElroy, J. F., Consolidated Car Heating Co., Chicago, Ill.
McElroy, John H., Consolidated Car Heating Co., Albany, N. Y.
McFarlin, J. R., Electric Service Supplies Co., Philadelphia, Pa.
McGee, J. G., Hildreth Varnish Co., New York, N. Y.
McGinn, Howard J., National Lock Washer Co., Chicago, Ill.
McGinnis, P. B., Westinghouse Air Brake, Chicago, Ill.
McGough, S. P., Lorain Steel Co., Chicago, Ill.
MacGovern, Frank, MacGovern & Co., New York, N. Y.
McGraw, Harold W., *Electric Railway Journal*, New York, N. Y.
McGraw, James H., President, *McGraw Publishing Co.*, New York, N. Y.
MacGuyer, H. F., D. & W. Fuse Co., Providence, R. I.
McIntire, A. H., Editor, *Electric Journal*, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
MacIntire, S. H., Pressed Prism Plate Glass Co., Chicago, Ill.
McIntosh, C. D., Joseph Dixon Crucible Co., Jersey City, N. J.
McKee, W. M., Peter Smith Heater Co., Detroit, Mich.
McKee, W. S., Vice-President, Edgar Allen American Manganese Steel Co., Chicago, Ill.
McKinney, E. B., Railway Improvement Co., New York, N. Y.
McLain, J. E., President, The Trolley Supply Co., Canton, Ohio.
McLain, W., Wm. Wharton Jr. & Co., Inc., Philadelphia, Pa.
MacLean, J. A., Boss Nut Co., Chicago, Ill.
McMaster, C. L., Pratt & Lambert, Chicago, Ill.
McMaster, R. K., Engineer, Kansas City Electric Light Co., Kansas City, Mo.
McMichael, J. G., President, Atlas Supply Co., Manhattan Building, Chicago, Ill.
McQuiston, J. C., Manager Department of Publicity, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
McWhorter, W. A., Galena-Signal Oil Co., Atlanta, Ga.
Mace, Romaine, Salesman, The Okonite Co., Ltd., 253 Broadway, New York, N. Y.

Members (Individual) in Attendance — (Continued).

Mallory, J. F., American Engineering Co., Philadelphia, Pa.
Mann, Henry S., Goldschmidt-Thermit Co., Chicago, Ill.
Marble, E. G., American Engineering Co., Philadelphia, Pa.
Markham, F. L., The J. G. Brill Co., Philadelphia, Pa.
Marsh, C. J., Manager, Standard Underground Cable Co., New York, N. Y.
Marsh, H. B., 931 Lemcke Building, Indianapolis, Ind.
Marsh, H. C., Salesman, General Electric Co., Cincinnati, Ohio.
Marshall, R. W., General Manager, Traction Materials Co., New York, N. Y.
Marshall, William, President, The Anglo-American Varnish Co, Newark, N. J.
Marston, Glenn, Public Service Publishing Co., Chicago, Ill.
Martindale, E. H., National Carbon Co., Cleveland, Ohio.
Marvel, Frank W., The Buda Co., Chicago, Ill.
Marys, Clifford P., Grip Nut Co., Chicago, Ill.
Mason, E. R., Electric Service Supplies Co., New York, N. Y.
Matheny, C. R., General Electric Co., Chicago, Ill.
Maujer, A. R., Hill Publishing Co., Chicago, Ill.
Maxson, H. W., Carnegie Steel Co., Pittsburgh, Pa.
May, J. P., Northey-Plummer, Ltd., Indianapolis, Ind.
Maycock, Joseph, Pratt & Lambert, 185 Madison Avenue, New York, N. Y.
Mayer, C. J., President, Electric Service Supply Co., Philadelphia, Pa.
Mayne, J. G., Galena Signal Oil Co., New York, N. Y.
Meeteer, Wesley, President, Wallace Supply Co., 26 Cortlandt Street, New York, N. Y.
Meissner, Edward B., St. Louis Car Co., St. Louis, Mo.
Mendenhall, J. B., Special Representative, National Lead Co., Liggett Building, St. Louis, Mo.
Merritt, W. G., The Chapman Valve Manufacturing Co., Chicago, Ill.
Methfessel, C. A., The Duff Manufacturing Co., New York, N. Y.
Metterhausen, Carl, Secretary, Wallace Supply Co., 120 North Jefferson Street, Chicago, Ill.
Meyer, Martin, Meyer Safety Guard Co., Omaha, Neb.
Midgley, Stanley, W., The Curtain Supply Co., Chicago, Ill.
Miles, J. G., Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Millen, J. E., Electric Service Supply Co., Philadelphia, Pa.
Miller, Frank D., President and Manager, National Brake Co., 88 Ellicott Square, Buffalo, N. Y.
Miller, R. E., Westinghouse Traction & Brake Co., Wilmerding, Pa.
Miller, Robert, Jr., General Electric Co., Salt Lake City, Utah.
Mills, Edwin S., Carnegie Steel Co., Chicago, Ill.

Members (Individual) in Attendance—(Continued).

Mills, Geo. F., Niles-Bement-Pond Co., Chicago, Ill.
Mills, S. H., Westinghouse Traction Brake Co., St. Louis, Mo.
Milton, T., Electric Storage Battery Co., Chicago, Ill.
Mitchell, H. M., Lyon Metallic Manufacturing Co., Aurora, Ill.
Mitten, A. G., Vice-President and General Manager, Dayton Fare Recorder Co., Philadelphia, Pa.
Moffett, J. McC., Manager, The Chapman Valve Manufacturing Co., Chicago, Ill.
Monroe, H. L., Manager Railway Department, General Electric Co., Chicago, Ill.
Montgomery, G. S., Universal Safety Tread Co., Boston, Mass.
Moore, John, The Egry Register Co., Dayton, Ohio.
Moore, R. E., General Electric Co., 1115 Witherspoon Building, Philadelphia, Pa.
Morris, L. P., Westinghouse Electric & Manufacturing Co., Boston, Mass.
Morton, G. L., Galena-Signal Oil Co., 403 Forsyth Building, Atlanta, Ga.
Mowry, J. G., Railway Representative, Patton Paint Co., Newark, N. J.
Mullaney, T. F., Chief Engineer, Third Avenue Railroad Co., New York, N. Y.
Mullhaupt, Alfred, Jr., Corliss Carbon Co., Bradford, Pa.
Mulligan, U. J., American Brake Shoe & Foundry Co. Chicago, Ill.
Munford, I. H., Valentine & Co., New York, N. Y.
Munoz, S. C., Duplex Metals Co., Chicago, Ill.
Myers, H. B., Office Manager, Edgar Allen American Manganese Steel Co., Chicago, Ill.
Nachod, C. P., General Manager, Nachod Signal Co., Philadelphia, Pa.
Nardini, A. M., Railway Track Work Co., Philadelphia, Pa.
Naylor, N. C., Railway Steel Spring Co., Chicago, Ill.
Neale, J. C., Assistant Manager Sales, Carnegie Steel Co., Pittsburgh, Pa.
Newton, H. E., New Tone System Co., Chicago, Ill.
Nicholas, Frederic, 1570 Old Colony Building, Chicago, Ill.
Nicholas, J. A., General Electric Co., Peoria, Ill.
Nicholson, S. L., Sales Manager, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Noble, D. C., Pittsburgh, Spring & Steel Co., Pittsburgh, Pa.
Noble, R. P., Westinghouse Air Brake Co., Chicago, Ill.
Noll, John, Continuous Rail Co., New York, N. Y.
Norris, H. E., Vice-President, The Eureka Co., North East, Pa.
Norris, W. K., McQuay-Norris Manufacturing Co., St. Louis, Mo.
Noyes, E. H., Aluminum Company of America, Chicago, Ill.
Nuckels, C. C., Consolidated Car Heating Co., Chicago, Ill.

Members (Individual) in Attendance — (Continued).

Oberlander, M. A., Western Electric Co., New York, N. Y.
O'Brian, T. P., The O. M. Edwards Co., New York, N. Y.
O'Connor, Wallace, National Carbon Co., Cleveland, Ohio.
Oelerich, J. F., Transportation Utilities Co., New York, N. Y.
Oesterreich, H. E., Wendell & Mac Duffie Co., 165 Broadway, New York, N. Y.
Ogden, F. H., Pennsylvania Steel Co., Harrisburg, Pa.
Ohmer, H. Beckman, Ohmer Fare Register Co., Dayton, Ohio.
Ohmer, J. F., President, Ohmer Fare Register Co., Dayton, Ohio.
Ohmer, W. I., Dayton Fare Recorder Co., Dayton, Ohio.
Olberding, A. G., American Brake Shoe & Foundry Co., Chicago, Ill.
Old, A. F., Manager, The Hale & Kilburn Manufacturing Co., 39 Union Square, New York, N. Y.
Olinger, C. S., Bayonet Trolley Harp Co., Springfield, Ohio.
Olmstead, C. J., Westinghouse Air Brake & Traction Brake Co., Chicago, Ill.
Olmstead, E. S., Chatham Electric Switching Device Co., Louisville, Ky.
Olsen, O. M., Spencer Otis Co., Chicago, Ill.
O'Malley, Owen, Electric Traction Supply Co., St. Louis, Mo.
Osborn, Frederick H., American Automatic Switch Co., New York, N. Y.
Osman, R. C., Globe Ticket Co., Philadelphia, Pa.
Ott, Ed., Lorain Steel Co., Johnston, Pa.
Pape, W. H., Galena-Signal Oil Co., Franklin, Pa.
Palmer, I. H., Galena-Signal Oil Co., Kansas City, Mo.
Parke, F. H., Westinghouse Traction Brake Co., Pittsburgh, Pa.
Parker, L. G., Assistant Manager of Sales, Cleveland Frog & Crossing Co., 6917 Bessemer Avenue, Cleveland, Ohio.
Parmenter, Geo. A., Parmenter Fender & Wheel Guard Co., Boston, Mass.
Partridge, A. S., 415 Pine Street, St. Louis, Mo.
Paton, James, The St. Louis Surfacer & Paint Co., St. Louis, Mo.
Patterson, J. Bradley, Midvale Steel Co., Philadelphia, Pa.
Paye, W. E., Berry Brothers, Ltd., Detroit, Mich.
Payne, Paul T., Dearborn Drug & Chemical Co., Chicago, Ill.
Pearce, H. G., Standard Steel Works, Philadelphia, Pa.
Pease, A. H., Secretary, Wason Manufacturing Co., Springfield, Mass.
Pease, L. M., National Brake & Electric Co., Chicago, Ill.
Peirce, Charles C., Manager, General Electric Co., Boston, Mass.
Pellissier, George E., Pellissier Engineering Co., Springfield, Mass.
Perkins, Alfred P., Western Electric Co., New York, N. Y.
Pero, H. G., Chicago Manager, McQuay Norris Manufacturing Co., St. Louis, Mo.
Perry, C. B., Lyon Metallic Manufacturing Co., Aurora, Ill.

Members (Individual) in Attendance — (Continued).

Perry, James W., General Manager Electric Department, The H. W. Johns-Manville Co., 100 William Street, New York, N. Y.
Peterson, Carl H., The Baldwin Locomotive Works, Philadelphia, Pa.
Phelan, M. J., Peter Smith Heater Co., Detroit, Mich.
Philbrick, F. H., Westinghouse Air Brake Co., Portland, Ore.
Philler, Wm. M., Pennsylvania Steel Co., Steelton, Pa.
Pierce, D. T., McGraw Publishing Co., New York, N. Y.
Piersen, Wm. J., The Adams & Westlake Co., Chicago, Ill.
Pierson, F. B., Manager, National Lead Co., Detroit, Mich.
Pietzcker, E. J., Southwestern Manager, Standard Underground Cable Co., St. Louis, Mo.
Pilcher, A. H., American Surety Co., New York, N. Y.
Pinckard, W. R., Westinghouse Electric & Manufacturing Co., Chicago, Ill.
Pine, W. J., Railway Utility Co., Chicago, Ill.
Pizzini, Andrew J., Railway Improvement Co., New York, N. Y.
Place, C. W., General Electric Co., Chicago, Ill.
Pollak, J. A., Pollak Steel Co., Cincinnati, Ohio.
Poole, S. K., Poole Bros., Chicago, Ill.
Porter, H. K., U. S. Metal & Manufacturing Co., Atlanta, Ga.
Porter, K. E., Carnegie Steel Co., Cincinnati, Ohio.
Post, George A., President, Standard Coupler Co., New York, N. Y.
Post, Geo. A., Jr., Sales Manager, Standard Coupler Co., New York, N. Y.
Potter, W. B., Engineer of Railway and Truck Department, General Electric Co., Schenectady, N. Y.
Porter, J. W., First Vice-President, Electric Service Supplies Co., 303 Dearborn Street, Chicago, Ill.
Pratt, C. E., Automatic Register Co., New York, N. Y.
Pratt, F. E., U. S. Metal & Manufacturing Co., New York, N. Y.
Price, E. C., Indianapolis Switch & Frog Co., Springfield, Ohio.
Price, Thomas, The Midvale Steel Co., New York, N. Y.
Price, W. G., Mechanical Engineer, Standard Motor Truck Co., 260 Reis Street, New Castle, Pa.
Priest, E. D., General Electric Co, Schenectady, N. Y.
Provost, Geo. W., Union Electric Co., Pittsburgh, Pa.
Pugh, W. H., Standard Steel Works, Philadelphia, Pa.
Radcliffe, H., Sales Manager, Vixon Tool Co., Philadelphia, Pa.
Raggio, V. C., General Electric Co., Dallas, Texas.
Rankin, Arthur W., National Surety Co., New York, N. Y.
Ransom, H. N., Near Side Car Co., Land Title Building, Philadelphia, Pa.
Rapp, J. P., Forged Steel Wheel Co., 170 Broadway, New York, N. Y.
Raynor, Clinton W., The National Surety Co., New York N. Y.

Members (Individual) in Attendance — (Continued).

Record, C. A., Galena Signal Oil Co., 369 Atlantic Avenue, Boston, Mass.

Reed, John R., Westinghouse Electric & Manufacturing Co., Vancouver, B. C., Canada.

Reed, Robert W., Sales Agent, Pennsylvania Steel Co. and Maryland Steel Co., Philadelphia, Pa.

Reel, George K., Pennsylvania Steel Co. and Maryland Steel Co., Chicago, Ill.

Reese, Geo. W., Lorain Steel Co., Johnstown, Pa.

Regester, C. W., Westinghouse Electric & Manufacturing Co., New York Life Building, Chicago, Ill.

Reisiger, Harry, The Hunter Illuminated Car Sign Co., Flushing, N. Y.

Rehm, N. F., Buyers' Index Co., Chicago, Ill.

Renshaw, C., Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.

Reynolds, Jno. N., Simmons-Boardman Publishing Co., Chicago, Ill.

Reynolds, W., Root Spring Scraper Co., Kalamazoo, Mich.

Rhoades, C. W., Valentine & Co., Chicago, Ill.

Rice, Ralph H., Electrical Engineer, Board of Supervising Engineers, Chicago, Ill.

Richards, C. L., The Galena Signal Oil Co., Hampton Hotel, Albany, N. Y.

Richards, F. C., The J. G. Brill Co., San Francisco, Cal.

Riley, W. T., American Bitumastic Enamel Co., Cleveland, Ohio.

Rinker, L. J., The Electric Railway Improvement Co., Cleveland, Ohio.

Robbins, A. E., Gold Car Heating & Lighting Co., New York, N. Y.

Robbins, F. C., President, Niles Car & Manufacturing Co., Cleveland, Ohio.

Robertson, C. E., Western Electric Co., St. Louis, Mo.

Robertson, M. W., Le Valley-Vitae Carbon Brush Co., New York, N. Y.

Robinson, John C., Wm. Wharton, Jr., & Co., Incorporated, Philadelphia, Pa.

Robinson, L., Standard Varnish Works, New York, N. Y.

Robinson, T. J., Ferguson Lange Foundry Co., Chicago, Ill.

Rockwell, C. H., The O. M. Edwards Co., Chicago, Ill.

Rooke, G. F., Rooke Automatic Register Co., Providence, R. I.

Root, F. N., Root Spring Scraper Co., Kalamazoo, Mich.

Root, Newton, Root Spring Scraper Co., Kalamazoo, Mich.

Rosenthal, George D., Manager, General Electric Co., 815 Wainwright Building, St. Louis, Mo.

Ross, James T., The Adams & Westlake Co., Chicago, Ill.

Ross, John J., U. S. Metal & Manufacturing Co., Chicago, Ill.

Members (Individual) in Attendance — (Continued).

Roth, F. W., J. N. Johns Manufacturing Co., New York, N. Y.
Rowntree, Bernard, Room 1774, 50 Church Street, New York, N. Y.
Rowntree, Harold, Prepayment Car Sales Co., Chicago, Ill.
Royal, C. B., Galena Signal Oil Co., Chicago, Ill.
Rubdell, Fred, The Eureka Co., North East, Pa.
Rubencame, E. W., Hessbright Manufacturing Co., Philadelphia, Pa.
Rumbley, F. N., Sales Engineer, St. Louis Steel Foundry, St. Louis, Mo.
Rummel, A. D., Duplex Metals Co., Chicago, Ill.
Russell, Richard, The Trigger-Lock Reversible Controller Finger, Toronto, Ont., Can.
Ryder, B. H., American Steel & Wire Co., Chicago, Ill.
Ryder, E. M. T., Engineer, Maintenance of Way, Third Avenue Railroad Co., New York, N. Y.
Rys, C. F. W., Metallurgical Engineer, Carnegie Steel Co., Pittsburgh, Pa.
Sager, F. W., The Midvale Steel Co., Philadelphia, Pa.
Salisbury, E. V., W. T. Van Dorn Co., Chicago, Ill.
Salsich, Neil E., Sales Agent, Pennsylvania Steel Co. and Maryland Steel Co., Steelton, Pa.
Sanger, Ralph, Wonham, Sanger & Bates, 30 Church Street, New York, N. Y.
Sauvage, W. H., Standard Coupler Co., New York, N. Y.
Sawtelle, C. E., Tool Steel Gear & Pinion Co., Cincinnati, Ohio.
Sawtelle, E. S., Tool Steel Gear & Pinion Co., Cincinnati, Ohio.
Sawyer, L. P., The Buckeye Electric Co., Cleveland, Ohio.
Saylor, Geo. A., Manager, Electric Department, H. W. Johns-Manville Co., 201 Clybourn Street, Milwaukee, Wis.
Schaffer, W. L., National Tube Co., Pittsburgh, Pa.
Schall, A. W., Niles Car & Manufacturing Co., Niles, Ohio.
Schauffler, C. E., Galena-Signal Oil Co., 319 Railway Exchange, Chicago, Ill.
Schlegell, V. Von, Hale & Kilburn Co., New York, N. Y.
Schluederberg, C. G., Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Schmidt, E. E., Electric Railway Improvement Co., Cleveland, Ohio.
Schmidt, E. H., The National Malleable Castings Co., Cleveland, Ohio.
Schumacher, Charles H., Chicago Pneumatic Tool Co., Chicago, Ill.
Schumacher, L. E., Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.
Scofield, S. W., Universal Lubricating Co., Cleveland, Ohio.
Scott, H. N., Griffin Wheel Co., Chicago, Ill.
Sedgwick, E. V., Galena Signal Oil Co., Franklin, Pa.
Seeber, Edward, Ohmer Fare Register Co., Dayton, Ohio.
Semple, C. B., Duplex Metals Co., Chicago, Ill.

Members (Individual) in Attendance — (Continued).

Shanahan, L. P., American Steel & Wire Co., Chicago, Ill.
Shepard, F. H., Westinghouse Electric & Manufacturing Co., 165 Broadway, New York, N. Y.
Sherman, H. R., Treasurer, New York Switch & Crossing Co., Hoboken, N. J.
Sherman, John, Near Side Car Co., Philadelphia, Pa.
Sherman, L. B., Simmons-Boardman Publishing Co., Chicago, Ill.
Sherwood, Frank H., American Brass Co., Ansonia, Conn.
Shugg, L. W., General Electric Co., Schenectady, N. Y.
Shute, Nathan, 1510 Land Title Building, Philadelphia, Pa.
Simmen, P. J., Northey-Plummer, Ltd., Indianapolis, Ind.
Simmons, F. G., Commissioner of Public Works, Milwaukee, Wis.
Simpson, J. G., Public Service Publishing Co., Chicago, Ill.
Sinclair, J. J., Westinghouse Electric & Manufacturing Co., 165 Broadway, New York, N. Y.
Sines, Harold S., Minerallac Electric Co., Chicago, Ill.
Sisson, A. H., General Manager, Forsyth Brothers Co., 31 E. Indiana Street, Chicago, Ill.
Slimp, J. E., District Sales Agent, Ohio Brass Co., 30 Church Street, New York, N. Y.
Slingluff, W. H., John A. Roebling's Sons Co., Chicago, Ill.
Slocum, C. V., Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.
Slocum, Frank S., Metallurgist, Jones & Laughlin Steel Co., Pittsburgh, Pa.
Small, T. W., The Acme Indicator Co., Cleveland, Ohio.
Smiley, J. B., Assistant Sales Agent, Pennsylvania Steel Co., 71 Broadway, New York, N. Y.
Smith, Alex., Buyers Index Co., Chicago, Ill.
Smith, C. H., Berry Brothers, Ltd., Detroit, Mich.
Smith, Delbert C., The Buda Co., Chicago, Ill.
Smith, D. W., President, The Peter Smith Heater Co., Detroit, Mich.
Smith, E. B., Salesman, American Brake Shoe & Foundry Co., 30 Church Street, New York, N. Y.
Smith, Elmer J., Peter Smith Heater Co., Detroit, Mich.
Smith, G. J., Galena Signal Oil Co., 6033 Jefferson Avenue, Chicago, Ill.
Smith, H. E., G. C. Kuhlman Co., Cleveland, Ohio.
Smith, H. E., Electric Traction, New York, N. Y.
Smith, O. P., The Esterline Co., Lafayette, Ind.
Smith, Oscar W., Bayonet Trolley Harp Co., Springfield, Ohio.
Smith, P. H., Westinghouse Electric & Manufacturing Co., Buffalo, N. Y.
Smith, R. C., Galena Signal Oil Co., Franklin, Pa.
Smith, W. N., Consulting Engineer, Yonkers, N. Y.

Members (Individual) in Attendance — (Continued).

Snyder, L. H., Manager, Lubricating Department, Joseph Dixon Crucible Co., Jersey City, N. J.

Southwell, J. Ernest, Mechanical Expert, Galena Signal Oil Co., New York, N. Y.

Speare, L. R., Special Agent, Galena-Signal Oil Co., 369 Atlantic Avenue, Boston, Mass.

Speer, J. S., President, Speer Carbon Co., St. Marys, Pa.

Sperry, Henry M., Sales Manager, General Railway Signal Co., Rochester, N. Y.

Spohr, Frank S., Green Engineering Co., Chicago, Ill.

Stacey, J. A., The Lorain Steel Co., New York, N. Y.

Stadelman, H. R., Nachod Signal Co., Philadelphia, Pa.

Stakelum, F. R., Galena Signal Oil Co., Franklin, Pa.

Stanton, Mark T., The Electric Railway Improvement Co., Cleveland, Ohio.

Stanton, W. T., General Electric Co., New York, N. Y.

Starkey, W. C., Chief Engineer, Ohio Brass Co., Mansfield, Ohio.

Steedman, J. H., St. Louis Steel Foundry, St. Louis, Mo.

Steiger, J. H., American Brake Shoe & Foundry Co., Chicago, Ill.

Steinbrenner, C. C., Galena Signal Oil Co., Franklin, Pa.

Steins, Halsey, W. J. Jeandron, New York, N. Y.

Stephenson, H. W., The National Malleable Castings Co., Toledo, Ohio.

Stewart, B. S., Standard Underground Cable Co., Chicago, Ill.

Stier, H. C., Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Stiff, H. C., Lorain Steel Co., Johnstown, Pa.

Stimson, David, Frank Ridlon Co., Boston, Mass.

Stockwell, Fred F., Treasurer, Barbour-Stockwell Co., Cambridge, Mass.

Storer, N. W., Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

Strail, F. A., Ohio Brass Co., Mansfield, Ohio.

Strong, James B., Assistant General Manager, Ramapo Iron Works, Hillburn, N. Y.

Stuckenholdt, H., The Whitmore Manufacturing Co., Cleveland, Ohio.

Sturdevant, Chas. R., Electrical Engineer, American Steel and Wire Co., Grove Street, Worcester, Mass.

Sullivan, D. A. J., Galena Signal Oil Co., Franklin, Pa.

Swan, Gideon W., Salesman, J. A. Roebling's Sons Co., D. S. Morgan Building, Buffalo, N. Y.

Sweet, Arthur J., Nelite Works, of General Electric Co., Cleveland, Ohio.

Swift, C. O., Crerar Adams Co., Chicago, Ill.

Swift, W. H., Westinghouse Electric & Manufacturing Co., Baltimore, Md.

Tate, H. F., National Conduit & Cable Co., Chicago, Ill.
Tawse, J. G., American Brake Shoe & Foundry Co., Chicago, Ill.
Taylor, E. S., Forsyth Brothers Co., Chicago, Ill.
Taylor, John, President, Taylor Electric Truck Co., Troy, N. Y.
Taylor, Walter E., Assistant Superintendent, Taylor Electric Truck Co., Troy, N. Y.
Tegler, L. A., Tool Steel Gear & Pinion Co., Cincinnati, Ohio.
Tell, R. P., Vice-President, National Brake & Electric Co., Park Place and River, Milwaukee, Wis.
Thode, Albert, A, Thode & Co., Hamburg, Germany.
Thomas, G. H., Whittier Mills Co., Chattahoochee, Ga.
Thomas, Perlay A., Southern Car Co., High Point, N. C.
Thomas, T. H., Westinghouse Air Brake, Pittsburgh, Pa.
Thompson, A. V., Railway Sales Agent, General Electric Co., Rialto Building, San Francisco, Cal.
Thomson, D., Atlas Supply Co., 38 Park Row, New York, N. Y.
Thompson, J. S., Chief Engineer, American Brake Shoe & Foundry Co., Chicago, Ill.
Thompson, R. H., The J. G. Brill Co., St. Louis, Mo.
Thorn, W., Division Engineer, Board of Supervising Engineers, 105 S. La Salle Street, Chicago, Ill.
Thurston, J. L., Hildreth Varnish Co., 90 West Street, New York, N. Y.
Tiemann, H. B., Carnegie Steel Co., Pittsburgh, Pa.
Tietze, Chas. F., The Midvale Steel Co., Philadelphia, Pa.
Tinnerholm, Aug. F., Mica Insulator Co., Schenectady, N. Y.
Titus, J. V. E., Second Vice-President, Electrical Service Supplies Co., Philadelphia, Pa.
Tomlinson, C. H., Ohio Brass Co., Mansfield, Ohio.
Tontrup, G. H., The J. G. Brill Co., Philadelphia, Pa.
Townsend, E. R., Engineer, 125 Monroe Street, Chicago, Ill.
Townsend, H. L., *Electric Traction,* Chicago, Ill.
Townley, Calvert, Assistant to President, Westinghouse Electric & Manufacturing Co., New York, N. Y.
Tratman, E. E. R., Editor, *Engineering News,* Chicago, Ill.
Travis, C. R., McQuay-Norris Manufacturing Co., St. Louis, Mo.
Trawick, S. W., Agent, Railway Department, General Electric Co., 30 Church Street, New York, N. Y.
Trist, N. B., Carnegie Steel Co., Pittsburgh, Pa.
Tritle, J. S., Westinghouse Electric & Manufacturing Co., Kansas City, Mo.
Trubee, W. A., Galena-Signal Oil Co., 26 Broadway, New York, N. Y.
Tupper, C. A., Allis-Chalmers Co., Milwaukee, Wis.
Turner, Henry G., The Adams & Westlake Co., Chicago, Ill.
Turner, O. E., General Electric Co., Chicago, Ill.
Turner, Sterling G., Atlanta Car Wheel and Manufacturing Co., Atlanta, Ga.

Members (Individual) in Attendance — (Continued).

Turner, W. V., Mechanical Engineer, Westinghouse Traction Brake Co., Pittsburgh, Pa.
Uthoff, O. W., Electric Traction Supply Co., St. Louis, Mo.
Vail, G. S., Branch Manager, Westinghouse Electric & Manufacturing Co., Cleveland, Ohio.
Valentine, L. B., Second Vice-President, Valentine & Co., 257 Broadway, New York, N. Y.
Van Angen, F., E. C. Long Co., New York, N. Y.
Van Buskirk, James, Minerallac Electric Co., Chicago, Ill.
Vandegrift, James B., Railway Roller Bearing Co., Syracuse, N. Y.
Van Doran, H. E., The W. T. Van Dorn Co., Chicago, Ill.
Van Dorn, Wm. E., The W. T. Van Dorn Co., Chicago, Ill.
Van Dorn, W. T., The W. T. Van Dorn Co., Chicago, Ill.
Van Patten, H. B., Murphy Varnish Co., Chicago, Ill.
Van Schaick, A. P., Lackawanna Steel Co., Chicago, Ill.
Van Stone, F. A., Lyon Metallic Manufacturing Co., Aurora, Ill.
Van Valkenburg, E. C., 2015 W. 102nd Street, Chicago, Ill.
Vehslage, E. C., Bonney Vehslage Tool Co., New York, N. Y.
Verner, A. L., Lorain Steel Co., Cleveland, Ohio.
Vickery, G. S., Pennsylvania Steel Co., Steelton, Pa.
Volkins, Wm. J., Treasurer, The International Register Co., Chicago, Ill.
Voorhis, H. M., Manager, Electric Department, H. W. Johns-Manville Co., 21 North Second Street, Philadelphia, Pa.
Wade, Scott, Heywood Brothers & Wakefield Co., Chicago, Ill.
Wade, W. O., Railway Improvement Co., New York, N. Y.
Walker, C. T., *Electric Railway Journal,* New York, N. Y.
Walker, Edmund H., Vice-President, Standard Coupler Co., 2 Rector Street, New York, N. Y.
Wallace, Chas. J., The Pantasote Co., Chicago, Ill.
Wallace, F. W., Waclark Wire Co., New York, N. Y.
Waller, E. P., Railway Department, General Electric Co., Schenectady, N. Y.
Wallerstedt, H., Chief Engineer, St. Louis Car Co., St. Louis, Mo.
Wallinger, Chas., Wallinger Co., Chicago, Ill.
Walsh, W. J., Resident Manager, Galena-Signal Oil Co., 319 Railway Exchange, Chicago, Ill.
Wampler, F., Master Mechanic, South Covington & Cincinnati Street Railway Co., Newport, Ky.
Wampler, William, Forsyth Brothers Co., New York, N. Y.
Ward, Charles W., Auto Signal & Appliance Co., Cleveland, Ohio.
Warren, J. J., The J. G. Brill Co., Philadelphia, Pa.
Waters, B. L., Lyon Metallic Manufacturing Co., Aurora, Ill.
Waters, Frank S., Lyon Metallic Manufacturing Co., Aurora, Ill.
Waters, R. T., Lyon Metallic Manufacturing Co., Aurora, Ill.

Members (Individual) in Attendance — (Continued).

Watkins, S. C., Sales Agent, Atlanta Car Wheel & Manufacturing Co., Atlanta, Ga.
Watts, G. E., Electric Service Supplies Co., Atlanta, Ga.
Weaver, H. P., Independent Inspection Bureau, Chicago, Ill.
Weaver, O. T., National Carbon Co., Cleveland, Ohio.
Weeks, W. H., Bryan Marsh Works of General Electric Co., New York, N. Y.
Wells, Lloyd R., The Midvale Steel Co., Chicago, Ill.
Wendt, P. W., Forged Steel Wheel Co.., Chicago, Ill.
West, W. C., Mechanical Expert, Galena-Signal Oil Co., 410 Traction Building, Indianapolis, Ind.
Weston, A. H., Mechanical Engineer, The T. H. Symington Co., Calvert Building, Baltimore, Md.
Weston, Geo., Member and Engineer Board of Supervising Engineers, 105 South La Salle Street, Chicago, Ill.
Whipple, A. L., Ward Equipment Co., 1915 Peoples Gas Building, Chicago, Ill.
Whistler, D. B., Secretary and Treasurer, Dayton Fare Recorder Co., Philadelphia, Pa.
White, C. B., Harrison Safety Boiler Works, Philadelphia, Pa.
White, F. P., Galena Signal Oil Co., Chicago, Ill.
Whitfield, W. V., Sterling Varnish Co., Pittsburgh, Pa.
Whyte, W. C., American Infusion Steel Process Co., New York, N. Y.
Wickwire, E. F., Ohio Brass Co., Mansfield, Ohio.
Wiley, J. R., Standard Underground Cable Co., 322 Rookery Building, Chicago, Ill.
Wilhelm, E., Boss Nut Co., Chicago, Ill.
Wilhelm, P. H., Standard Leather Packing Co., Boston, Mass.
Wilkinson, A. L., Ohio Brass Co., Mansfield, Ohio.
Williams, C. P., National Lock Washer Co., Chicago, Ill.
Williams, E., Manager, Street Railway Sales Department, Sherwin Williams Co., Cleveland, Ohio.
Williams, H. S., Peter Smith Heater Co., 47 Brady Street, Detroit, Mich.
Williams, L. A., Flood & Conklin Co., Newark, N. J.
Williams, R. W., Westinghouse Traction Brake Co., Atlanta, Ga.
Williams, T. W., Carnegie Steel Co., General Sales Department, Pittsburgh, Pa.
Willis, Geo. E., District Sales Agent, Ohio Brass Company, 456 Peachtree Street, Atlanta, Ga.
Wilson, H. G., Flood & Conklin Co., Newark, N. J.
Wilson, H. M., Vice-President, The McGraw Publishing Co., 239 West 39th Street, New York, N. Y.
Wilson, J. Mac Naul, Wilson Remover Co., New York, N. Y.
Wilson, James Whitney, Wilson Remover Co., New York, N. Y.

Members (Individual) in Attendance — (Continued).

Wilson, Robert L., Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.
Wilson, S. M., Advertising Manager, The J. G. Brill Co., 5205 Chester Avenue, Philadelphia, Pa.
Wilt, B. C., McCord Manufacturing Co., Chicago, Ill.
Winger, Stanley D., Green Engineering Co., Chicago, Ill.
Wisler, Bond, American Electrical Works, Phillipsdale, R. I.
Witherby, Edwin E., General Vehicle Co., Chicago, Ill.
Woeber, R. L., 79 Logan Street, Denver, Colo.
Woltman, Ernst, A. & J. M. Anderson Manufacturing Co., Chicago, Ill.
Wood, C. N., C. N. Wood Co., Boston, Mass.
Woodruff, E. C., Professor, Electrical Engineering, James Milliken University, Decatur, Ill.
Worley, John, Jr., Lyon Metallic Manufacturing Co., Aurora, Ill.
Wright, C. P., American Brake Shoe & Foundry Co., Chicago, Ill.
Wright, D. B., Lehon Company, Chicago, Ill.
Wright, E. E., McKeen Motor Car Co., Chicago, Ill.
Wright, John B., Westinghouse Traction Brake Co., Pittsburgh, Pa.
Wright, W. V. D., Railway Steel Spring Co., Chicago, Ill.
Wundrack, O., Ferguson Lange Foundry Co., Chicago, Ill.
Wyse, J. F. H., 25 Victoria Street, Toronto, Can.
Yates, De Forrest, Recording Register & Fare Box Co., New Haven, Conn.
Young, C. D., Goldschmidt Thermit Co., Chicago, Ill.
Zadek, J. L., New York Switch & Crossing Co., Hoboken, N. J.
Zulauf, F. H., The Van Dorn & Dutton Co., Cleveland, Ohio.

GUESTS IN ATTENDANCE

(Representatives of Electric Railway and Steam Railroad Companies.)

Beaver Valley Traction Co.:
Allhouse, Wm. F., Track Foreman.
Meyer, Henry, Line Foreman.
Peterson, P. N., Master Mechanic.

Buffalo, Lockport & Rochester Railway Co.:
Prather, H. C., Superintendent of Motive Power.

Burlington Traction Co.:
Brownell, C. B., Superintendent of Motive Power.

Calumet & South Chicago Railway Co.:
Lucas, S. B., Master Mechanic.

Guests in Attendance—(Continued).

CHICAGO HEIGHTS RAILWAY CO.:
McCoy, W. H., Engineer.

CHICAGO & NORTHWESTERN RAILWAY CO.:
Chinney, R. M., Assistant Engineer, Signal Department.
Pratt, F. S., Assistant Superintendent of Motive Power.

CHICAGO, ROCK ISLAND & PACIFIC RAILROAD:
Barrey, J. B., Chief Engineer.
Sholtz, Carl, Engineer.
Shurtleff, A. R., Office of Engineer.

CINCINNATI, GEORGETOWN & PORTSMOUTH RAILROAD:
Jonas, E. J., Electrical Engineer.

EVANSVLLE, SUBURBAN & NEWBURGH RAILWAY CO.:
Clinard, A., Master Mechanic.

FT. DODGE, DES MOINES & SOUTHERN RAILROAD:
Duncan, John, Master Mechanic.

GARY & INTERURBAN RAILWAY CO.:
Alger, Frank, Master Mechanic.

HAMMOND, WHITING & EAST CHICAGO RAILWAY CO.:
Schall, W. J., Master Mechanic.

JOLIET & SOUTHERN TRACTION CO.:
Catchpole, E., Master Mechanic.
Morrison, J. E., Chief Engineer.

KANKAKEE ELECTRIC RAILWAY CO.:
Dosen, Frank, Master Mechanic.

MICHIGAN CENTRAL RAILROAD:
Franks, E. A., City Purchasing Agent.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD:
Rhodes, R. S., Electrical Department.

NORFOLK & SOUTHERN RAILROAD:
Davis, H. W., Purchasing Agent.

OMAHA RAILWAY CO.:
Haskett, R. M., Engineer.

PORT ARTHUR & FORT WILLIAM ELECTRIC RAILWAY CO.:
Fox, R., Superintendent of Electric Lighting.
Jones, L. M., Engineer.

PUBLIC UTILITIES CO.:
Garinger, James J., Superintendent of Roadway.

ROCHESTER, SYRACUSE & EASTERN RAILROAD CO.:
Flatley, M. F., Master Mechanic.

SAINT LOUIS ELECTRIC RAILWAY CO.:
Barnhart, J. D., Master Mechanic.

SOUTHERN PACIFIC RAILWAY CO.:
Stephens, C. E., Road Master.

Guests in Attendance—(Continued).

SOUTHERN TRACTION CO.:
Dean, L., Engineer.

WAUSAU STREET RAILROAD CO.:
Jensen, Neils, Master Mechanic.

WINONA INTERURBAN RAILWAY CO.:
Sigler, Charles, Electrical Engineer and Master Mechanic.

(OTHER GUESTS.)

Apranharson, A. L., Manager, Electric Light & Telephone Co., Fort William, Canada.
Belcher, W. E., Chief Draftsman, H. M. Byllesby, Chicago, Ill.
Bement, A., Consulting Engineer, Chicago, Ill.
Bidwell, J. N., Assistant Engineer, Railroad Service Department, Wisconsin Railroad and Tax Commission, Madison, Wis.
Blakesley, James E. Jr., Inspector, Board of Supervising Engineers, Chicago, Ill.
Boyd, William S., Electrical Inspector, 76 West Munroe Street, Chicago, Ill.
Brooks, Mr., Board of Supervising Engineers, Chicago, Ill.
Carr, M. L., Underwriters Laboratories, Inc., Chicago, Ill.
Coffman, J. A., Engineer, Board of Supervising Engineers, Chicago, Ill.
Cooke, W. P., Jr., Chairman, Electric Light & Telephone Co., Port Arthur, Canada.
Cooper, F. H., Assistant Engineer, Board of Supervising Engineers, Chicago, Ill.
Corbett, J. O., President, Corbett & DeCoursey, Pittsburgh, Pa.
Crumpton, William J., Manager Chicago Office, D. C. & W. B. Jackson, Chicago, Ill.
Davidson, Charles J., American Society of Mechanical Engineers, Chicago, Ill.
Dean, Stanley, Civil Engineer, Chicago, Ill.
Dodd, A. N., Electrical Engineer, Public Service Commission, New York, N. Y.
Dunlap, G. W., Public Service Commission, 1st District, New York, N. Y.
Elfborg, H. G., Chief Engineer, Ajax Forge Co., Chicago, Ill.
Emerson, J. B., Southeastern Manager, Robert W. Hunt Co., St. Louis, Mo.
Engleke, B. L., Engineer, Knox Engineering Co.
Feustal, R. M., Engineer, Staff Engineer, Railroad Commission, Madison, Wis.
Ford, Grant, Engineer, Knox Haskett Co., Chicago, Ill.
Foster, George B., Commonwealth Edison Co., Chicago, Ill.
Gennett, C. W. Jr., Engineer, Robert W. Hunt Co., Chicago, Ill.

Other Guests in Attendance—(Continued).

Gerber, W. D., W. S. Shields Co., Chicago, Ill.

Gibbons, T. P., Foreman, Conway Construction Co., Chicago, Ill.

Goodman, H. E., President, Goodman Manufacturing Co., Chicago, Ill.

Gregg, L. F., Chief Clerk, Electrical Department, Sanitary District Light & Power Co., Chicago, Ill.

Hadin, Gus, Engineer, Sanitary District Light & Power Co., Chicago, Ill.

Knox, George W., Jr., Oklahoma Railway Co., Oklahoma City, Okla.

Lawrence, E. H., Civil Engineer, Chicago, Ill.

Lynch, W. J., Board of Supervising Engineers, Chicago, Ill.

McCollum, Burton, Electrical Engineer, National Bureau of Standards, Washington, D. C.

McNeil, Thomas W., Chief Engineer, Reid Murdock & Co., 951 Laurel Ave., Chicago, Ill.

Mahan, James S., Electrical Inspector, Electrical Inspection Bureau, 76 W. Monroe Street, Chicago, Ill.

Norsa, R., Electrical Engineer, Member American Institute of Electrical Engineers, Chicago, Ill.

Ong, J. R., Assistant Electrical Engineer, 355 E. 30th Street, Madison, Wis.

Patterson, Hugh, Electrical Engineer, Chicago Electrification Commission, Chicago, Ill.

Power, C. W., Chief Engineer, City of Toronto, Toronto, Ontario, Canada.

Raiguel, Wm. M., Engineering Inspector, Board of Supervising Engineers, Chicago, Ill.

Rodgers, J. F., Field Engineer, Board of Supervising Engineers, Chicago, Ill.

Steeg, F. W., Chief Draftsman, Board of Supervising Engineers, Chicago, Ill.

Thompson, W. T., Board of Supervising Engineers, Chicago, Ill.

Wright, William, Consulting Engineer, Pullman Company, Chicago, Ill.

MINUTES

OF THE

1912 CONVENTION

MONDAY AFTERNOON SESSION

OCTOBER 7, 1912

The tenth annual Convention of the American Electric Railway Engineering Association was called to order in the Brown Room of the Saddle and Sirloin Club, Chicago, Illinois, at 2.30 P. M. with President Ackerman in the Chair.

PRESIDENT ACKERMAN:—The first thing on the program is as usual the address of the president and I shall take but a few moments of your time.

ADDRESS OF THE PRESIDENT

It is a high honor to address you at this, the opening of the tenth annual Convention of our Association, as its executive officer. It affords us a great deal of pleasure to greet the many members and friends of this and other allied associations that have assembled here in Chicago to take part in the Convention, and we are especially glad to extend this welcome to those who have come to assist us in our work.

We are particularly fortunate in the selection of Chicago, the metropolis of the Middle West, as the Convention City, where the electric railway men of the United States, Canada, Mexico and South America, from Cape Breton to Hawaii and Manila, and from Winnipeg to Montevideo, are greeted with the magnificent hospitality of her citizens and the hearty welcome of her officials.

The diffusion of knowledge in the art of electric railway transportation should enable us to render more efficient service to the public,

EDITOR'S NOTE.—A complete list of the names of those who participated in the discussion at the various meetings of this Convention, together with their official titles, etc., will be found on the page following the minutes of the last Session.

whose gratitude will be reflected in a spirit of more friendly relations. The companies which you represent will have reason to expect that after this week of conference with men of similar vocations, where topics of common interest are discussed, you will be made stronger and better engineers and able to handle more efficiently the every-day problems, and the enthusiasm of the gentlemen now assembled in Chicago is the assurance that they will not be disappointed.

Your Executive Committee has made little or no change this year in the general method of handling the work of the Association. It has responded most generously to the call of your officers for counsel, for which I wish most heartily to thank its members. In selecting subjects for consideration by the various committees, your Executive Committee found the field expanding so rapidly that it was not possible to treat every subject presented with the usual number of committeemen. It therefore selected and assigned for consideration this year only those subjects which in its judgment were of the most importance. I might add that it seems desirable that the number of members on committees should be further increased in order that all of the subject matter desired by your Executive Committee may be thoroughly considered and our Association thereby keep in advance of the actual needs of its constituents. The response to the call for members to take up committee work this year was most generous, and the zeal and painstaking care with which the work was prosecuted is very gratifying. While many of the committeemen were extraordinarily busy wth their regular professional work they have generously labored in the interest of the Association, and the results of the deliberations of your committees are to be commended. They have given us an excellent set of reports comprising some 500 pages of printed matter which have been in your hands for some time, and as you are all familiar with the recommendations of the committees which are to come before you for consideration I trust the discussions will be full, free and to the point.

To the gentlemen of the committees who have labored so diligently during the year I wish to express my sincere thanks and assure them that the Association is truly grateful for their long-continued and efficient service and its excellent results.

I regret that on account of the large amount of professional work on hand with the men who were most experienced and have been most interested in the training of mechanical apprentices it was decided to omit the Committee on Education of Engineering Apprentices for this year. In view of the great importance to the railway companies of the training of mechanics in railway work and the deep interest taken in the subject by members of our Association, it is recommended that a committee be appointed to continue the work during the coming year, and as the work is largely the training of young men to become good

mechanics, it is suggested that the name of the committee be changed to the Committee on the Education of Mechanical Apprentices.

You will note from the reports that several committees and subcommittees have been working this year jointly with other associations, and representatives of other associations have conferred with our committees in the consideration of subjects of mutual interest. As a result the subjects have received consideration from a wider viewpoint and the reports have received much added value. The spirit of co-operation is highly beneficial and should be widened to the broadest extent.

The adoption of proper "Standards" and "Recommended Practices" by the Association is of such prime importance to the economical construction and operation of electric railways as to demand the closest attention and consideration by every member of our Association, and I trust that the recommendations of the committees, which are in your hands, will be weighed with great care and your approval registered accordingly. While the method for the consideration and adoption of "Standards" and "Recommended Practices" adopted at our last Convention is of great value to the Association, there is need of further revision so that the work may be more effectively carried into the practice of our member companies. While we look upon the list of "Standards" and "Recommended Practices" already adopted with a large degree of satisfaction, the work has only just begun and the Association is to be congratulated upon the progress it has already made in that direction.

The American Electric Railway Association has, in its wisdom, begun the publication of a monthly magazine, devoted to the electric railway industry, upon the advisory board of which the several allied Associations are represented. The advent of the AERA is hailed by the engineers with great satisfaction and marks the beginning of a greater usefulness of the Association to the individual. It will greatly assist in the interchange of ideas and create a desire in, and afford the opportunity to, the individual member to study the electric railway business more thoroughly than ever before and enable him to keep in close touch with the work of his associates. It thrills him with enthusiasm and drives him to a higher standard of efficiency. It will broaden the scope of knowledge in the art with marvelous rapidity, and the Association is to be congratulated upon the excellency of the publication.

In order that the work of our Association should be more effective and the Association receive due credit for the diffusion of knowledge and the increasing of the efficiency of its members, it has been suggested and is desirable that each member of our Association should file with the executive officer of the company which he represents a written report of all the information of value obtained at the Con-

vention, with suggestions as to how said information may be employed in the betterment of local conditions.

In closing I wish to express my high appreciation of the work of our Secretary, who, notwithstanding the fact that his regular professional duties have been largely increased and duties of Secretary of this Association have been multiplied, has faithfully and efficiently carried on the work of Secretary of this Association. To him we are indebted to a large degree for the success with which we have met, and I, therefore, tender to him the hearty thanks of the Association.

PRESIDENT ACKERMAN:— The next order of business is the Report of the Executive Committee, which will be presented by Secretary Litchfield.

SECRETARY LITCHFIELD:— Gentlemen, before making the report of the Executive Committee, I would like to call your attention to a notice in the official program, which asks, that members taking part in discussions give their names to the official stenographer. If you had been in my position for the last two years you would have some sympathy with us on that score. We try to send a transcript of each member's remarks to him for revision and if you make any extended remarks, even with the best stenographers you will be surprised to see how your remarks sometimes look in proof.

ANNUAL REPORT OF EXECUTIVE COMMITTEE

To the American Electric Railway Engineering Association:

GENTLEMEN:— Two meetings of your Executive Committee were held during the year, one at New York on November 17 and 18, 1911, and one here at Chicago, October 7, 1912; and below are shown a record of the business transacted at these meetings:

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF THE AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION HELD AT THE ASSOCIATION HEADQUARTERS, 29 WEST 39TH STREET, NEW YORK, N. Y., NOVEMBER 17 AND 18, 1911.

A meeting of the Executive Committee was held at the Association Headquarters, November 17 and 18, 1911, the meeting being called to order by President Ackerman, on November 17, 1911, at 9:30 A. M.

Those present were Messrs. E. O. Ackerman, President; Martin Schreiber, First Vice-President; L. P. Crecelius, Second Vice-President; John Lindall, Third Vice-President; J. H. Hanna, E. J. Burdick, B. F. Wood, H. H. Adams, and Norman Litchfield, Secretary, and Rodney Hitt, of the *Electric Railway Journal,* and George R. Blodgett, of the *Electric Traction Weekly,* were also present.

Minutes of Preceding Meetings

The minutes of the meeting of the Committee held at Atlantic City on October 9, 1911, were read and approved.

The minutes of the after Convention meeting of the Committee on Standards, held November 6 and 7, were then abstracted by the Secretary. The results of this meeting are shown in the report of the Committee on Standards.

Outline of Work for Year

President Ackerman then outlined the work to be done by the Association during the coming year and requested advice from all the members of the Executive Committee in regard to committee appointments.

The necessity of the furtherance of close co-operation with the various local Electric Railway Associations was then brought up, especial attention being called to the fact that these local Associations are often compelled to reach a prompt conclusion in regard to matters of standardization, but that nevertheless it is highly desirable that as far as possible the local and American Associations should work along the same lines, and that existing discrepancies should be done away with. This matter was further amplified by President Ackerman, and Mr. Burdick stated that as a member of the Central Electric Railway Association, he felt that the general opinion of the members of that Association was that such a result was highly desirable. A motion was then carried instructing the Secretary of the Engineering Association to attend meetings of such Associations as the President sees fit to select, in order to keep in touch with the general work in hand.

The work which has been done during the past year in co-operation with other engineering bodies was then discussed and attention was called to the existence of certain subcommittees which have been appointed from the standing committees of the Engineering Association to work with these outside engineering bodies in the investigation of certain specific matters. It was the opinion of the Executive Committee that it would be highly desirable to keep the personnel of these subcommittees the same until the particular matter in hand reaches a conclusion, as it is evident that if the personnel of the subcommittees should change entirely each year the work would be very greatly hampered. To this end, a motion was passed that the Chairman of the Standing Committees be requested to follow the policy as far as practicable of continuing in service a majority or all of the members of subcommittees which are working in conjunction with other engineering societies.

Method of Handling Work at the Convention

The matter of handling work at the Convention was then thoroughly discussed, the suggestion being advanced that it might become necessary to split the sessions. This did not seem to be desirable to the

Executive Committee as a whole and it was felt rather that better use of the time now allotted should be made, and a motion was therefore passed that the Chairmen of the Standing Committees be instructed to submit the names of men to be requested to submit written discussions or discuss the report orally, and also that the Secretary be instructed to send out a circular letter to all members and associates at the time of sending out the advance papers, inviting oral and written discussions.

It was also suggested that discussions on the floor of the Convention be limited to the definite recommendations of the Committees and that other matters included in the reports as suggestions or papers should not form subject for discussion on the floor.

It was further felt that the report of the Committee on Standards should be considered by the Convention as a whole, whereas under the present system it is in danger of being discussed only by that group of men who are especially interested in the report of that particular standing committee, such as Way, Equipment, etc., which is to be presented at the same session as the report of the Committee on Standards. A motion was therefore passed that one entire meeting of the Engineering Association be set aside solely for the presentation of the report of the Committee on Standards. The actual time at which this session is to be held was discussed, but no decision was reached and the matter was left open for future settlement.

Appointment of Subcommittee on Publications

The volume of the matter entering into the proceedings of the Engineering Association was then discussed and the necessity pointed out of the existence of some committee to exercise an editing power on the reports of the Committees and a motion was thereupon passed that a subcommittee on Publications, consisting of three members of the Executive Committee, be appointed to edit all papers, the duties of this Committee being to advise the Secretary on such matters as to which there might be a question in his mind.

Appropriation

A motion was then passed that the American Association be requested to make an appropriation of $3,500 for the use of the Engineering Association, including salaries.

Associate Membership

The desirability of the substitution of some other title for that of "Associate Member" was then discussed and Mr. Ackerman was delegated to take up the matter with the Executive Committee of the American Association.

Assignment of Subjects for Committee Work

The subjects for 1912 were then taken up and allotted to the different committees as follows:

COMMITTEE ON EQUIPMENT

High Grade Rubber Insulating Compound: The 1911 Convention recommended joint action of the Committees on Equipment and Power Distribution in further investigation of the subject of the 30 per cent. Pure Para Rubber Insulation. In the judgment of the Executive Committee this title is inadequate and the above was therefore substituted.

Couplers for Interurban Cars and End Connections on Cars: The Committee on Equipment is to confer with the Committee on Heavy Electric Traction and to take such action as is necessary to act with the Central Electric Railway Association, the American Railway Association and the American Railway Engineering Association.

Self Propelled Cars: Preparation of a resumé of the experience with actual installations to date. The subject of Storage Battery Car had been referred to the Engineering Association by the American Association but the Executive Committee felt that this title was inadequate and the above was therefore substituted.

Heat Treated Pinions and Gears:

End Wear on Journals:

Specifications for Cold Rolled Axles and Ordinary Carbon Steel Axles:

Squealing of Steel Wheels:

Heat Treated Axles: Consideration of the revisions suggested on the floor of the 1911 Convention and in the meeting of the Committee on Standards, and such other revisions as may be brought up during the year. Subject to be handled by the Subcommittee now working in conjunction with the American Society for Testing Materials.

A motion was passed that the subject of Rolled Steel Wheels for One Wear be deferred for one year.

A motion was passed that the Gauge for Mounting Wheels, both Steel and Chilled, be laid on the table.

COMMITTEE OF WAY MATTERS

The consideration of a nine-inch Girder-Grooved and Guard Rail, and a seven-inch Girder-Grooved and Guard Rail, embracing the principles outlined in the report of the Committee on Way Matters for 1911.

The consideration and further development of Rail Joint outlined in the report of the Committee on Way Matters for 1911.

Proper Ballast for Track in Paved Streets.

The use of titanium, nickle and chromium, or any other cleansing material in the manufacture of Rails. To be handled by the Sub-

committee now acting in conjunction with the American Society for Testing Materials.

The Matter of Rules for the Government of Employees of the Way Department was brought up and the policy of adopting such rules was questioned by Mr. Schreiber in a written communication. Mr. Hanna, as a member of the Committee on Standards, then outlined the majority report of that Committee in regard to this matter. As a result of the discussion a motion was carried that the Committee on Standards be advised that rules of a general nature, such as the Rules for the Government of Employees of the Way Department submitted by the Committee on Way Matters for 1911 and the Rules for Fire Protection submitted by the Committee on Buildings and Structures for 1911, should not be adopted as "Recommended Practice" or "Standard," but should simply be included in the proceedings and presented to the American Association as a guide. The foregoing being the case, it was not deemed advisable to refer this matter back to the Way Committee.

The Secretary was instructed to write to the Committee on Way Matters for 1911 that the Executive Committee wishes to thank them for their work and feels that these Rules will be of considerable value to the Member Companies as a guide.

Meeting then adjourned until 9:30 A. M., November 18th.

The meeting of November 18, 1911, called to order at 10 A. M. by President Ackerman.

Those present were: Messrs. E. O. Ackerman, E. J. Burdick, J. H. Hanna, John Lindall, L. P. Crecelius, Martin Schreiber, Norman Litchfield, Secretary, and Mr. Rodney Hitt of the *Electric Railway Journal.*

ASSIGNMENT OF SUBJECTS FOR COMMITTEE WORK — *Continued*

JOINT-COMMITTEE ON ENGINEERING ACCOUNTING

Inter-Departmental Charges:

Cost of Power: What shall be included in it? Shall depreciation and obsolence be considered operating and maintenance charges? (Before this subject is assigned to the Committee the American Association is to be consulted as to whether this will form a desirable subject.)

COMMITTEE ON POWER GENERATION

Methods of Selecting Faulty High Tension Cables at the Power House.

Chemical Laboratory Practice in Connection with Power Work.

Peak Loads.

Boiler Settings and Furnace Design with a special reference to power plants built on the common main basis or unit plan basis.

The above subjects are to be the main considerations of the Committee and the following to receive attention in addition if possible:

The possibilities of the gas engine as a power generator in the immediate future, with special attention to the limitations in size imposed by present conditions and development.

The possibilities of gas producers for:

(a) anthracite coal.

(b) bituminous coal.

Best arrangement of automatic relays and other switching apparatus to protect power plant from shutdowns.

The application of distant control principle to all important valves in power plant, with reference to concentration of control in some point of the plant remote from the possibilities of damage.

COMMITTEE ON POWER DISTRIBUTION

Specifications for the Joint Use of Poles.

Specifications for Overhead Crossings of Trolley Contact Wires Over Railway Tracks.

Specifications for Overhead Crossings of Foreign Wires with Electric Railway Wires.

Concrete, Latticed and Tubular Poles, including settings for iron poles.

High Grade Rubber Insulating Compound. (To be handled by joint action of Committees on Equipment and Power Distribution.)

The above subjects are to be the main consideration of the Committee and the following subjects to receive attention if possible:

Standard Stranding Table.

Revision of the Copper Wire Table now a Standard of the Association.

COMMITTEE ON BUILDINGS AND STRUCTURES

General Specifications and Form of Contract for Railway Structures.

Review of Modern Car House Construction, with Recommendations.

Proper Waiting Rooms and Shelters for Electric Railways.

COMMITTEE ON HEAVY ELECTRIC TRACTION

A motion was passed that the consideration or non-consideration of the subject of Automatic Train Stops be left to the judgment of the Committee, and that if it is considered it would be well to act in conjunction with the American Railway and American Railway Engineering Associations.

Permanent way construction lines as bearing upon the space required for the installation of third-rail working conductors, with a view to recommending a standard which will be satisfactory to the Committees of the American Electric Railway Engineering Associa-

tion, American Railway Association and American Railway Engineering Association.

Power consumption in connection with the handling of trains by electric locomotives.

JOINT-COMMITTEE ON BLOCK SIGNALS

A motion was passed that the Executive Committee take up with the Transportation and Traffic Association the desirability of appointing two additional members to the Committee from each Association and if the Transportation Association concurs, instructions are to be issued to the co-chairman to take such action.

The general subject of Block Signals to be continued.

COMMITTEE ON ENGINEERING APPRENTICES

Continuation of the general subject of Education of Engineering Apprentices.

The Secretary was then instructed to write the Central Electric Railway Association, advising them of the action taken by the Executive Committee, instructing the Secretary of the Engineering Association to be present at the annual meeting of the Central Association.

An amendment to the Code of Instructions for Standing Committees was then passed requiring that all reports should contain a roll call of the Committee Members present at each meeting.

The Secretary was instructed to request the American Association to have the Standards of the Association printed in a separate volume to be sent to each member and associate.

A motion was passed that a Committee on Subjects, consisting of two members of the Executive Committee be appointed at the close of the Convention by the incoming Executive Committee to report to the Executive Committee at its first meeting with suitable subjects for the ensuing year.

The President was authorized to appoint a Committee to investigate the desirability of revising the Constitution and By-Laws.

A committee consisting of Messrs. Schreiber and Litchfield was appointed to prepare suitable resolutions to be presented to Letter Ballot by the Executive Committee with a view to presenting this resolution to the Executive Committee of the American Association, in regard to delegates to the Convention preparing reports to their executives and with a further view to insuring that the Engineering Association receive due credit for improvements brought about in operation, which have originated in the attendance of the delegates of Member Companies at the Convention.

REPORT OF THE COMMITTEE ON REVISION OF CONSTITUTION AND BY-LAWS

To Mr. E. O. Ackerman, President:

A meeting of the committee appointed by the Executive Committee to look into possible revisions of the Constitution and By-Laws of the Engineering Association was held in New York City, July 2, 1912. Those present being Messrs. H. H. Adams, W. J. Harvie, Martin Schreiber and Norman Litchfield.

After considerable discussion it was decided that it was the sense of the Committee that at present it would not be well to make any revisions either in the Convention or the method of governing the Association. It was felt, however, that certain executive action should be taken, and the following Resolutions were therefore passed:

First.— That the Committee recommend to the Executive Committee that this year the President be requested to appoint a Committee on Nominations, composed of three past presidents and two members at large not members of the Executive Committee, and present a ticket to the Executive Committee at least one month in advance of the Convention.

Second.— That the Committee recommend to the Executive Committee that the Committee on Nominations be informed that it is the sense of the Committee on Revision that the interests of the Engineering Association would be best served by the retention in office of a majority of the members of the Executive Committee from year to year.

Third.— That the Executive Committee upon receiving the report of the Committee on Nominations shall submit to all Company Members the approved ticket and advise them that the ticket is to be voted upon by ballot at the Convention, the ballots to be duly signed by the Company's accredited representative and that these ballots may be presented at the Convention or sent in by mail in advance of the Convention. Ballots will be received up to 6 P. M. of the day preceding the closing day of the Convention. Results of the election to be announced at the last Convention session and officers installed in the manner prescribed by the constitution and by-laws. Ballots are to be counted by three tellers appointed in the Convention by the presiding officer.

Fourth.— That the Committee recommends that the present arrangement of the organization should not be changed, but it believes an increased efficiency will be obtained by assigning to each vice-president a definite part of the Association's activity for which he will be responsible to the President and the Executive Committee.

It is suggested that the three vice-presidents be assigned, as may seem desirable to the President, to the following lines of the Association's work:

(a) Association and committee membership.
(b) Publications.
(c) Finances (with particular reference to the apportionment of the Association's money).

In explanation of these three points, it should be said that the idea of the first was that one vice-president should make it a point to acquaint himself with the qualifications of members for service on technical committees and the Executive Committee, so that men who

are particularly versed in some one special branch of the art may become easily available for appointment by the President to any committee. It is recognized that at the present time it is very difficult for the President to get information as to new members, and that therefore a procedure such as above outlined will be of great help to the President and of benefit to the Association.

(b) Publications: It will be the duty of this vice-president to familiarize himself and keep in touch with the various engineering matters which are to be published in the AERA and in the Proceedings.

(c) Finances: It will be the duty of this vice-president to see that the expenditure of the Association's money is made in the manner most advantageous to the Association.

(d) It is further recommended in case at any time it becomes advisable to elect as Secretary and Treasurer of the American Electric Railway Engineering Association the Secretary and Treasurer of the American Electric Railway Association, that owing to the technical nature of the work the President is to appoint a member of the Executive Committee to confer with the Secretary.

Respectfully submitted,

H. H. ADAMS, *Chairman,*
NORMAN LITCHFIELD,
MARTIN SCHREIBER,
W. J. HARVIE,
Committee on Revision of Constitution and By-Laws.

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF THE AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION HELD IN CHICAGO, ILL., OCTOBER 7, 1912.

A meeting of the Executive Committee was held at the Congress Hotel, Chicago, Ill., October 7, 1912, the meeting being called to order by President Ackerman at 9:30 A. M. The following gentlemen were present: Messrs. E. O. Ackerman, President; Martin Schreiber, Vice-President; L. P. Crecelius, Second Vice-President; J. H. Hanna, E. J. Burdick, H. A. Mullett and Norman Litchfield, Secretary.

The resignation of the Secretary, as printed below, was first presented and discussed.

AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION

OFFICE OF SECRETARY-TREASURER, 98 STREET AND 3D AVENUE
NEW YORK, N. Y., *September* 11, 1912.

MR. E. O. ACKERMAN, *President,* and Members of the Executive Committee of the American Electric Railway Engineering Association:

GENTLEMEN.—The writer has come to the conclusion that the field of the Engineering Association has broadened to such an extent that the interests of its members would be best served by the consolidation of the office of its Secretary with that of the American Association. The detail work has been rapidly increasing and to continue the present policy of having as Secretary an engineer actively engaged in professional work would, in my judgment, require the regular employment of paid assistants.

This would, of course, involve considerable expense and, furthermore, the experience of the past year convinces me that the work could be more effectively handled in the office of the General Secretary.

I therefore present my resignation to take effect upon the election of the new officers at the coming Convention.

Yours very truly,
NORMAN LITCHFIELD,
Secretary-Treasurer.

The report of the Secretary-Treasurer was then read. (This report is given in full on pages 89 and 90.)

A motion was passed to invite Past President F. G. Simmons in the name of the Association to be present at the meetings.

Information was presented from the Secretary of the American Electric Railway Association to the effect that only about fifty Member Companies had replied to the letter ballot on Standards. Discussion then followed on the apparent ineffectiveness of the present method of adopting Standards and a resolution was passed suggesting to the incoming Executive Committee that arrangements be made for the submission to Member Companies for vote, only those matters approved by the Engineering Association as Standards, and that matters for Recommended Practices receive the approval of the Engineering Association only; and further, that instead of obtaining the vote of the American Association by letter ballot, that the recommendation of the Engineering Association for Standards be presented and acted upon at either the Annual or Mid-Winter meetings of the American Association. It was also recommended that matters recommended for adoption as Standard be carefully restricted to those of vital interest to all Member Companies and which would admit of and are in proper shape for general adoption by all. These suggestions would in effect, form a revision of the existing code of Rules for Procedure for the Adoption of Standards.

The Committee on Nominations was then appointed as follows: Messrs. H. H. Adams, *Chairman,* Charles H. Clark, William Roberts, W. J. Harvie and J. M. Yount.

Respectfully submitted,

Approved:

E. O. Ackerman,
President.

Norman Litchfield,
Secretary.

President Ackerman:— Gentlemen, you have heard the report of the Executive Committee. What is your pleasure?

(On motion by Mr. Palmer, duly seconded and stated, the report was accepted and placed on file.)

President Ackerman:— We will now hear the report of the Secretary-Teasurer.

ANNUAL REPORT OF THE SECRETARY-TREASURER FOR THE FISCAL YEAR ENDED SEPTEMBER 30, 1912

To the American Electric Railway Engineering Association:

Gentlemen:— At the request of the Executive Committee of the Engineering Association, the American Association granted an appropriation of thirty-five hundred dollars ($3,500) for the work of the Engineering Association during 1911–1912. The work of the Com-

mittees, however, was found to be so great that, notwithstanding unusual efforts to reduce expenses, it was found that the expenditures would exceed the amount of the appropriation. Upon conference with the Secretary of the American Association, it was decided to hold those vouchers exceeding the appropriation until after September 30th, the close of the fiscal year, which has been done. This will leave a considerable charge against the coming year's appropriation. To guard against the repetition your Secretary-Treasurer recommends that definite amounts be apportioned to each Committee so that the Chairman can regulate his expenditures accordingly.

EXPENDITURES

On vouchers duly approved by the President and Secretary.	$3,265 28
By the Secretary of the American Association.....	5,476 94
Total charged against appropriation.....	$8,742 22

This expenditure was made for the following purposes:

Proceedings, 1911	$5,167 32
Salary of Secretary, 1911–1912.....	275 00
Secretary's Office Expenses, 1911–1912.....	219 10
President's Office Expenses, 1911–1912.....	35 73
Convention Expenses, 1911.....	41 03
Executive Committee Expenses, 1911–1912.....	168 00
Standing Committee Expenses, 1911–1912.....	2,836 04
Total Expenditures 1911–1912.....	$8,742 22

Respectfully submitted,

NORMAN LITCHFIELD,
Secretary-Treasurer.

PRESIDENT ACKERMAN:— Gentlemen, you have heard the report of the Secretary-Treasurer. What is your pleasure?

(On motion by Mr. Adams, duly seconded and stated, the report was accepted and placed on file.)

PRESIDENT ACKERMAN:— The next order of business is the presentation and consideration of reports of committees. Before proceeding with the reports, I desire to call attention to the desirability of confining the discussion to the subject matter contained in the reports of the committees. The time for the consideration of each report is definitely fixed by our program, and it will be necessary to hold the time for each paper within that time limit.

We will have presented to us first, the report of the Committee on Power Distribution, of which Mr. George W. Palmer, Jr., is chairman, and I will ask Mr. Palmer to come forward and present the report.

MR. PALMER:— The report of the Committee has been printed in advance and has been distributed, so that the members have had an opportunity to familiarize themselves with it. I shall not attempt to read any portion of the report, but will bring out a few points in connection with some of the specific topics.

One of the very live questions which the Engineering Association and the Committee on Power Distribution had to consider, was the Specifications for the Joint use of Poles, referred to on page 97. The Committee on Power Distribution in its consideration of that matter, at the direction of the Executive Committee, had reached the point where conferences had been arranged for with duly accredited representatives of the other interests involved. Just at or about that time, however, as the result of a communication from the New York Electric Railway Association to the American Electric Railway Association, a special committee was appointed by that Association to take up this matter and consider some phases of it in addition to those which the Committee on Power Distribution were considering. Consequently all action on this matter since that date (early in the Spring) has been taken by the Committee on Joint Use of Poles which was appointed by the American Association, of which Mr. W. J. Harvie is chairman. The Committee on Power Distribution, therefore, has finished consideration of this subject, except as it may be further requested to go into the matter by the special committee.

Specifications for Overhead Crossings of Trolley Contact Wires over Railway Tracks and Specifications for Overhead Crossings of Foreign Wires with Electric Railway Wires: The treatment which those subjects should receive at the hands of this Association we feel should be largely governed by the action that the Association takes in relation to the Specifications for Overhead Crossings of Electric Light and Power

Transmission Lines, and the Committee feels that discussion of these topics which are noted on page 98 of the report, should be deferred until after the discussion of the high tension wire crossing matter.

As to the matter of concrete and tubular poles, the subcommittee having the matter in hand has done considerable work, but the Committee as a whole is only able to report progress at this time.

Referring to the subject of High-grade Rubber Insulating Compound, the members will recall that at the last Convention the Committee on Power Distribution had under consideration a report on 30 Per Cent. Para Rubber Compound. At the instance, as I understand it, of certain members of the Committee on Equipment and, people who were concerned in equipment matters, the subject was referred back to the Committee on Power Distribution for consideration jointly with the Committee on Equipment. The course which the matter has taken amounts to this, as I understand it. The Committee on Equipment consider that they have little, if any, use for 30 per cent. Para rubber compound, and are not particularly interested in the matter. For various reasons noted somewhat at length in the report, nothing has been accomplished this year, and we are at the same stage in relation to this matter that we were last year. The Committee on Power Distribution, however, feels that it needs and need as soon as it may be brought about, specifications for 30 per cent Para rubber compound, and wire insulated with that compound, both for submarine and underground cable use, and we feel that the necessities of the Committee on Equipment, or the necessities of people interested in equipment with respect to wire with different insulation should not be allowed to delay consideration of this subject.

There has been some consideration given in the past to the matter of stranding (noted on page 101), and there has been work outside of that as accomplished by this Committee, both by the Bureau of Standards of the United States Government and by the American Institute of Electrical Engineers. The Stranding Table referred to in the report was printed in Circular No. 31 of the United States Bureau of Standards and

relative to that circular I have a letter from the Secretary of the Standards' Committee of the American Institute of Electrical Engineers as follows:

"The tables of Circular No. 31 of the Bureau of Standards have not been finally adopted by the A. I. E. E., as stated in the circular, but they have been approved by the Standards Committee, and the standard of copper resistivity employed in computing the tables has been recommended by the International Committee on Standards of the International Electrotechnical Commission at the last meeting of that Committee in Paris in May last. No official action has as yet been taken by either the A. I. E. E. or the I. E. C., although there is little doubt of such action."

In compliance with the direction of the Executive Committee, the Committee on Power Distribution considered the subject of Trolley Guards and has made a report on it (noted on page 103). That report, I may say, when it went to the Committee on Standards, was referred back to the Committee on Power Distribution as certain members of the Committee on Standards, felt that the recommendation should not be adopted as it stood, and further, that this matter of trolley guards was a detail of standard overhead construction a subject now being considered by the Committee on Power Distribution, and should be taken up in connection with that subject.

The revision of the Specifications for High Tension, Three Conductor, Paper Insulated, Lead Covered Cable and for Single Conductor, Paper Insulated Lead Covered Cable for 1200 Volts (pages 102 and 103), are of minor importance, except that the conductivities have been changed and the specifications are now in accordance with the proposed standard wire tables, both for stranding and resistance.

There is extended reference made to the matter of the Revision of Specifications for Overhead Crossings of Electric Light and Power Transmission Lines. At the time the Committee took its last action on this matter, the specifications had not been adopted as standard by the steam railroad interests. We are now informed through the chairman of the General Committee which considered this subject that the American Railway Association has recommended the adoption of these specifications with some revisions which however, have not

come to hand. The Committee on Power Distribution has felt that the report should be revised in certain respects, which are indicated on page 107.

With reference to Section 1, Scope, page 107, which provides "These specifications shall apply to overhead electric light and power line crossings (except trolley contact wires) over railroad right of way, tracks or lines of wires; and, further, these specifications shall apply to overhead electric light and power wires of over 5,000 volts constant potential, crossing, or construction over telephone, telegraph or other similar lines."

The Committee did not believe that the scope of the specification should be so extensive, and, therefore, recommended, that the latter part of the specification should be eliminated, so that it should read as follows:

"1, Scope: These specifications shall apply to Overhead Electric Light and Power Line Crossings (except trolley contact wires) over railroad right of way, tracks, or lines of wires."

As to the next topic — Specifications for Trolley Wire. The Committee reported specifications to the 1911 Convention, which were adopted and passed to the Committee on Standards. This last named Committee approved the specifications and they went to letter ballot, and were I believe, adopted by a majority of the votes cast on that ballot. There seemed to be more or less feeling, however, that it was hardly creditable that the Committee on Power Distribution, in developing specifications which differed from the specifications on this matter formulated by the American Society for Testing Materials, could have been acted in the right direction. The American Society for Testing Materials contested our specifications very strongly, particularly the torsion test, and maintained that it was absolutely unnecessary, disclosed nothing, and imposed additional hardships on the manufacturer. Your Committee, however, was convinced that the specifications were right. Since the last Convention there have been several meetings between subcommittees of the American Society for Testing Materials and the Committee on Power Distribution with the result that "we have met the enemy and they are ours."

The representatives of the American Society for Testing Materials now admit that the tests which the Committee on Power Distribution recommended are tests which will disclose defects in trolley wires which none of the tests in their specifications would disclose, and the only question now between us is the minimum number of turns which should be prescribed as being necessary to disclose any existing defect. The matter is progressing toward a satisfactory settlement, but in the meantime we feel that we should "stand pat" on our specifications, and not modify the number of prescribed turns until an agreement has been reached by both Associations.

Standard Sections of Grooved Trolley Wire: The Committee submits an enlarged drawing to make plain its previous intention.

In connection with Electric Wire and Cable Terminology. This matter has had more or less discussion and action by this Committee and Association and I desire to read a communication from Dr. A. E. Kennelly, Chairman of the Standards Committee of the American Institute of Electrical Engineers as follows:

"Secretary Hutchinson of the American Institute of Electrical Engineers has referred to me your inquiry of June 19. I beg to say that the Standards Committee appointed a subcommittee early this year, to investigate electric wire and cable terminology. The report showed that there was considerable difference of opinion among different manufacturers on certain terms employed in the wire and cable business. The Standards Committee decided not to put out any authorized set of definitions. It requested the Bureau of Standards, however, to prepare such a circular and employ in this circular the definitions which received in the main the assent of the Committee. The definitions issued by the Bureau of Standards are, therefore, official with the Bureau, and are recommended by the Standards Committee, but no final official action has yet been taken by the Standards Committee. It is possible that after a year or so, if the terminology becomes uniform with that adopted by the Bureau, the Standards Committee may take final action."

As to the proposed specifications referred to at the top of page 111, these are merely tentative, and are some which have been used by companies in the past and are merely printed in this report for the purpose of discussion and the development of information.

REPORT OF THE COMMITTEE ON POWER DISTRIBUTION

To The American Electric Railway Engineering Association:

GENTLEMEN.— The Committee on Power Distribution submits the following report:

The Executive Committee of the American Electric Railway Engineering Association assigned to the Committee on Power Distribution the followng subjects, for consideration this year:

1. Specifications for the Joint Use of Poles.
2. Specifications for Overhead Crossings of Trolley Contact Wires over Railway Tracks.
3. Specifications for Overhead Crossings of Foreign Wires with Electric Railway Wires.
4. Concrete, Lattice and Tubular Poles, including Settings for Iron Poles.
5. High Grade Rubber Insulating Compound.
6. Standard Stranding Table.
7. Revision of the Copper Wire Table, now a **Standard** of the Association.
8. Trolley Guards.

Shortly after the 1911 Convention, the Committee on Standards referred the following subjects to the Executive Committee with the request that they be called to the attention of this year's Committee on Power Distribution.

1. Revision of Specifications for High Tension Three Conductor Paper Insulated Lead Covered Cable.
2. Revision of Specifications for Single Conductor Paper Insulated Lead Covered Cable for 1200 Volts.
3. Revision of Specifications for Overhead Crossings of Electric Light and Power Transmission Lines.

At the last Convention, there was evident a desire that the Specifications for 00 Round Hard-Drawn Copper Trolley Wire, recommended by the Committee for adoption as "Standard," and so adopted and referred to the Committee on Standards (page 161, 1911 Proceedings), and the Specifications of the American Society for Testing Materials for Hard-Drawn Copper Wire, be made to harmonize if possible, through joint action by the Committee on Power Distribution and a Committee from the American Society for Testing Materials. This subject therefore has been so jointly considered.

Meetings of the Committee were held at the Association headquarters in New York, February 23 and 24; all members present, except Messrs. Palmer (absent on account of illness), Cadle and Hayden;

May 23 and 24, all members present except Mr. Corning (absent on account of illness).

At these meetings, and by correspondence during the remainder of the year, the above-named subjects were considered and conclusions reached as follows:

SPECIFICATIONS FOR THE JOINT USE OF POLES

The increasing demands of municipalities that separate lines of wires, formerly carried on different lines of poles, be supported by one line of poles to be used by all parties in common, and the fact that frequently the interests of the different pole and wire owning companies required such joint use of poles has demonstrated the need of a standard form of agreement and specification for the joint use of poles.

This subject has been considered for several years by the National Electric Light Association and at its meeting in New York City, May 29 to June 2, 1911, its Committee on Overhead Line Construction made a report of which such a specification and agreement formed a part, with the recommendation that it be adopted as a national standard.

The American Electric Railway Engineering Association had no part in the formulation of this agreement and specification, nor was it invited to be a party thereto.

The Committee on Power Distribution, at the 1911 Convention, reported that it had prepared an outline draft of specifications for the joint use of poles, had tentatively adopted the same, and stated that it felt that the Association should communicate with various other Associations interested with a view to preparing a specification which would be satisfactory to all the interests involevd, and further suggested that such action be taken by the 1912 Committee (page 86, 1911 Proceedings).

On January 12, the Chairman wrote President Ackerman, stating that it was desirable to promptly begin conferences of the several interests and requested that he communicate with the National Electric Light Association and the American Telephone & Telegraph Company, asking them to name representatives to take part in the conferences, and notifying them that this Association would be represented by the Committee on Power Distribution.

President Ackerman so wrote on January 15, and on January 26 was notified by Mr. J. J. Carty, Chief Engineer, American Telephone & Telegraph Co., that his company would be glad to co-operate fully and would be represented by Mr. H. S. Warren and Mr. F. L. Rhodes. On January 29, the National Electric Light Association notified him that Mr. Farley Osgood, General Superintendent, Public Service Electric Co., Newark, N. J., and Mr. W. T. Oviatt, General Superintendent, Narragansett Lighting Co., Providence, R. I., would represent that Association.

On January 25, however, at a meeting of the Executive Committee of the American Electric Railway Association, the Chairman was instructed to appoint a Committee to be known as the Joint Pole Committee, to review the whole subject of the joint use of poles. Mr. W. J. Harvie was appointed Chairman of this Committee and the Committee on Power Distribution given representation on it through its Vice-Chairman, Prof. A. S. Richey.

It is therefore recommended that the Committee on Power Distribution be discharged from further consideration of this subject, except at the request of the Joint Pole Committee.

SPECIFICATIONS FOR OVERHEAD CROSSINGS OF TROLLEY CONTACT WIRES OVER RAILWAY TRACKS

The Committee reported at the last Convention that an outline draft of a Specification for Overhead Crossings of Trolley Contact Wires over Railway Tracks had been prepared and tentatively adopted and recommended that the Association communicate with other interests involved with a view to securing united action and the adoption of a specification by all the parties at interest. It was suggested that such action be taken by the 1912 Committee (page 86, 1911 Proceedings).

At the meeting on May 23 and 24, the specifications adopted by last year's Committee were thoroughly reviewed and in some respects revised, but it was decided that this matter should not be taken up with the other parties at interest until the policy of the American Electric Railway Association in connection with this and other kindred subjects should be developed. The reasons for this are more fully set forth in the discussion of the subject "Specifications for Overhead Crossings of Electric Light and Power Transmission Lines."

The specifications as shown in Appendix A of this report are given with a view to developing discussion and comments of benefit to the Committee in a further consideration of this subject.

SPECIFICATIONS FOR OVERHEAD CROSSINGS OF FOREIGN WIRES WITH ELECTRIC RAILWAY WIRES

The Committee reported at the last Convention that an oultine draft of a specification for Overhead Crossings of Foreign Wires with Electric Railway Wires had been prepared and tentatively adopted and recommended that the Association communicate with the other parties interested with a view to securing united action and the adoption of a specification by all parties involved. It was suggested that such action be taken by the 1912 Committee (page 86, 1911 Proceedings).

At the meeting of May 23 and 24, the specifications adopted by last year's Committee were thoroughly reviewed and in some respects revised. It was decided, however, that this matter should not be taken up with the other parties at interest until the policy of the American Electric Railway Association, in connection with this and other related subjects, should be developed.

The reasons for this are more fully set forth in the discussion of the subject "Specifications for Overhead Crossings of Electric Light and Power Transmission Lines."

The specifications (Appendix B of this report) are given with a view to bringing out discussion and comments of benefit to the Committee in a further consideration of this subject.

CONCRETE, LATTICE AND TUBULAR POLES, INCLUDING SETTINGS FOR IRON POLES

The Committee regrets that at this time its investigation of this subject has not reached a point that will permit it to submit a final report.

It hopes, however, at the next Convention, to be able to recommend Standard Specifications for Concrete, Tubular and perhaps Lattice Poles, suitable for the most common uses of such structures.

HIGH GRADE RUBBER INSULATING COMPOUND

At the last Convention, the Committee submitted specifications for 30 Per Cent. Para Rubber Compound and recommended its adoption as Standard (pages 86, 158, 1911 Proceedings).

It appearing in the subsequent discussion that the Committee on Equipment was strongly interested in the subject of rubber insulation, the Association referred the subject back to the Committee on Power Distribution and instructed, that it be taken up in conjunction with the Committee on Equipment, for report to the 1912 Convention (page 159, 1911 Proceedings).

The Executive Committee also felt that the title "30 Per Cent. Para Rubber Compound" was inadequate and suggested instead "High Grade Rubber Insulating Compound."

The Committee feels, however, that in its specification it had intended to describe a particular grade of rubber insulating compound, requiring a certain definite admixture of Para rubber and that it was not intended in this specification to consider the matter of various grades of rubber insulation, one or several of which might be termed "high grade."

On January 12, the Chairman wrote the Chairman of the Committee on Equipment, requesting that he appoint a Subcommittee to act with the Subcommittee of the Committee on Power Distribution with a view to considering this subject at a joint meeting to be held on January 26, in New York. Messrs. Patterson, Clark and Blair formed the Subcommittee of the Committee on Equipment and Messrs. Corning, Thompson and Barnard, the Subcommittee of the Committee on Power Distribution.

The proposed meeting was, because of the illness of the Chairman, postponed until February 24, at which time there were present Messrs. Corning, Thompson and Barnard of this Committee, and Mr. Blair of the Committee on Equipment. After outlining a definite course of procedure the Joint Subcommittees adjourned.

Shortly after this meeting the Subcommittee of this Committee and the Committee itself met with serious loss by reason of the continued illness of Mr. Corning, rendering it impossible for him to further pursue Committee work this year. For this reason the Chairman requested the Chairman of the Subcommittee of the Committee on Equipment to take the initiative in the further consideration of this matter in order that a satisfactory report could be made to the 1912 Convention.

Mr. Patterson therefore called a meeting of the Subcommittees for June 13 at Cedar Point, Ohio. At this meeting there were present Messrs. Thompson of the Committee on Power Distribution and Patterson of the Committee on Equipment, who decided that on account of the illness of Mr. Corning and the continued inability of other members of the Subcommittees to attend, it would not be possible this year to take further action in reference to the specification for this particular grade of insulation.

Mr. Thompson transmitted to the Committee that portion of the minutes of the June 14 meeting of the Committee on Equipment as referred to this subject, from which it appeared that the question having been raised as to whether the cost of this high grade insulation would justify its use in the equipment of rolling stock, the Committee on Equipment felt that the subject was deserving of much more investigation and consideration than could be given under present instructions, and recommended that the subject of specifications for wires and cables for equipment purposes, including the quality of insulation and construction of wires and cables for different voltages and carrying capacities, be assigned to that Committee for the coming year.

It appears from the foregoing, that no progress has been made in the matter of Specifications for High Grade Rubber Compound and that, we are at the same point on this subject as we were at the 1911 Convention.

The Committee at that time had a definite specification, which it recommended for adoption, but action was deferred in order that the Committee should work in conjunction with the Committee on Equipment on this particular specification (page 159, 1911 Proceedings).

The Committee feels that the attempt to develop a standard specification for 30 Per Cent. Rubber Compound should not be delayed by the doubtless desirable attempt to generally standardize the specifications for wires and cables for equipment purposes.

A standard insulation of this grade is strongly needed for power distribution purposes, there being but comparatively small use for other grades of rubber insulation for similar purposes.

The Committee therefore recommends that it be authorized to con tinue its consideration of this grade of insulation, in order that it may submit to the 1913 Convention, standard specifications for various sizes

and kinds of wire and cable, insulated with this grade of compound. If the Committee on Equipment is interested in this particular grade of compound, the Committee on Power Distribution would be glad to consider the subject jointly. As lengthy consideration will be necessary, the desirability of prompt action is suggested.

STANDARD STRANDING TABLE

At the last Convention the Committee reported that it had taken up the matter of a "Standard" stranding table for all sizes of cable but stated that it had been unable to reach a definite conclusion on the matter and that as the Standards Committee of the American Institute of Electrical Engineers had the subject of a standard stranding table under consideration, the Committee felt that action by the Association should be deferred until definite action had been taken by the American Institute of Electrical Engineers (page 111, 1911 Proceedings).

The Bureau of Standards of the United States Department of Commerce and Labor in its Circular No. 31, published April 1, 1912, pages 50 and 51, gives the properties of bare concentric cables of standard annealed copper in both standard strands and flexible strands, English and metric units.

These tables are in accord with the standards adopted by the Standards Committee of the American Institute of Electrical Engineers, both in respect to the number of wires in standard strands and in flexible strands and also with regard to the correction for increase of resistance and mass due to the twist of the wires.

The Committee has recommended in its report to the Committee on Standards, that Table IV, referred to under the heading "Revision of the Copper Wire Table, etc.," which is based upon the above-named tables, be adopted by the Association as "Standard."

REVISION OF THE COPPER WIRE TABLE, NOW A STANDARD OF THE ASSOCIATION

A new value for the standard resistivity of annealed copper has been adopted by the Bureau of Standards and the American Institute of Electrical Engineers, and has also been agreed upon at an International Conference between representatives of United States, Germany and France. The new value is to be known as the *Annealed Copper Standard* and is equivalent to 0.15328 ohm (meter, gram) at 20 deg. C.

This value in various units is equal to:

875.20 ohms (mile, pound) at 20 deg. C.
1.7241 microhm — circular mil, at 20 deg. C.
0.67879 microhm — inch at 20 deg. C.
10.371 ohms (mil, foot) at 20 deg. C.

(The term "ohms" (mile, pound) is exactly equivalent to "pounds per mile-ohm," which is sometimes used).

Based upon the Annealed Copper Standard, the following named Tables have been prepared, which the Committee recommends for adoption as Standard, superseding the **Standard** Copper Wire Table adopted in 1910:

Table I, Complete copper wire table, in English units.
Table II, Complete copper wire table, in Metric units.
Table III, Working copper wire table, in English units.
Table IV, Table of bare concentric cables, in English units.

Complete data on the relations of length, mass, and resistance of annealed copper wires of the American Wire Gauge sizes are given in Tables I and II, pages 32 to 47. Table I gives the data in English units, Table II in Metric units. The quantities involving resistances are given at 6 temperatures: 0 deg. C, 25 deg. C, 50 deg. C, 75 deg. C, and the two widely used standard temperatures 15 and 20 deg. C. The mass per unit length and length per unit mass are given without specification of temperature because they vary so slightly with temperature; the density from which they are computed is taken to be correct at 20 deg. C.

The quantities in the tables were computed to five significant figures, and have been rounded off and given to four significant figures. The results are believed to be correct within one in the fourth significant figure.

It is appreciated that four significant figures greatly exceeds in precision the uses to which a wire table is put. This table is intended, however, chiefly as a sort of ultimate reference table, and for a practical working table of annealed copper wire, Table III is recommended. This is an abbreviated form of the complete Table I, intended to facilitate ready reference by the practical user.

Table IV gives data on bare concentric lay cables of annealed copper. The diameter of the strands was calculated from the specified total cross section of the cable, divided by the number of wires. The "Number of Wires" for "Standard Strands" and "Flexible Strands" are those adopted by the Standards Committee of the American Institute of Electrical Engineers in January, 1912.

The Committee also presents Table V, giving data for average commercial hard-drawn aluminum wire at 20 deg. C of the American Wire Gauge sizes. It is based on a figure furnished by the Aluminum Company of America as representing the mean conductivity of its output for all sizes of wire for five years past.

The Committee has recommended in its report to the Committee on Standards that Tables I and II be adopted by the Association as Standard; also that an abbreviated table (Table III), based upon Tables I and II, be adopted by the Association as a "Standard" Working Table.

Tables I, II, III, IV and V, hereinbefore mentioned, are given in full in Appendix C of this report.

TROLLEY GUARDS

The Committee is very strongly of the opinion that the additional hazard introduced by the use of trolley guards is not generally warranted by the benefit derived therefrom, and feels that as the cases where they can be used with any net benefit are exceptions to what they believe should be the general rule, trolley guards should not be used.

It is the unanimous sentiment of the Committee that the inherent dangers at railroad crossings are best minimized by simple and correct construction of the overhead line wires, and by maintaining the track in good line and surface.

The Committee therefore have recommended in their report to the Committee on Standards that the following be adopted by the Association as "Recommended Practice"— Trolley Guards should not be used, except possibly in unusual cases due to complicated alignment of the crossing track.

REVISION OF SPECIFICATIONS FOR HIGH TENSION, THREE CONDUCTOR, PAPER INSULATED, LEAD COVERED CABLE

At the 1911 Convention the Committee on Power Distribution submitted a specification on this subject, recommending that it be adopted by the Association as "Standard" (pages 86, 142, 1911 Proceedings).

The specifications were approved by the Association and referred to the Committee on Standards for adoption as "Standard" (page 158, 1911 Proceedings).

At the subsequent meeting of the Committee on Standards, in the discussion of this subject, the question was raised as to a possible element of doubt in some portions of the specifications, and it was decided to request the Executive Committee to ask the incoming Committee on Power Distribution to further consider these specifications, with a view to possibly presenting a revision at the next convention.

The Committee on Standards, by unanimous vote of the members present, then approved the specifications for adoption as "Standard" and the matter therefore went to the letter ballot of the member companies of the Association.

The Committee has exhaustively considered the specifications and in its report to the Committee on Standards has recommended the following revision in specifications as printed in the Proceedings of 1911:

Page 87, Title,

"Specifications for High Tension, Three Conductor, Paper Insulated, Lead Covered Cables." to be changed to, "Specifications for High Voltage, Three Conductor, Paper Insulated, Lead Covered Cable."

Conductors: Strike out the words "Intermediate sizes take the stranding of the next larger listed size."

The paragraph, "Each of the individual wires shall have a conductivity of not less than 98.5 per cent. of pure soft copper by the standard adopted by the American Institute of Electrical Engineers," to be

changed to, "Each of the individual wires shall have a resistivity of not more than 888.55 ohms (mile, pound) at 20 deg. "C."

The paragraph as to stranding is unnecessary, as by the new stranding table, the sizes of conductors quoted in the specifications have the same number of wires.

The conductivity prescribed by the specifications "98.5 per cent. of pure soft copper by the standard adopted by the American Institute of Electrical Engineers," is in the revision expressed in specific instead of relative terms, and is the resistivity of copper corresponding to 98.5 per cent. of the conductivity of the new Annealed Copper Standard.

The Committee recommends that no further revision be made in these specifications.

REVISION OF SPECIFICATIONS FOR SINGLE CONDUCTOR, PAPER INSULATED, LEAD COVERED CABLE FOR 1200 VOLTS

At the 1911 Convention, the Committee submitted specifications on this subject, recommending that it be adopted by the Association as "Standard" (pages 86, 142, 1911 Proceedings).

The specifications were approved and referred to the Committee on Standards for adoption as "Standard" (page 159, 1911 Proceedings).

At the subsequent meeting of the Committee on Standards, in the discussion of this subject, the question was raised as to a possible element of doubt in some portions of the specifications, and it was decided to request the Executive Committee to ask the incoming Committee on Power Distribution to further consider these specifications, with a view to possibly presenting a revision at the next Convention.

The Committee on Standards, by unanimous vote of the members present, then approved the specifications for adoption as "Standard" and the matter therefore went to the letter ballot of the Member Companies of the Association.

The Committee has exhaustively considered the specifications, and in its report to the Committee on Standards, has recommended the following revisions in the specifications, as printed in the Proceedings of 1911:

Page 93, *Conductor:* The following stranding,

Size of conductor	Number of wire
1,100,000–1,900,000 c. m.	91
2,000,000 and larger	127

to be changed to,

Size of conductor	Number of wires
1,100,000–1,500,000 c. m.	91
1,600,000 and larger	127

in order that it accord with the proposed new "Standard" Stranding Table.

That the paragraph, "Each of the individual wires shall have a conductivity of not less than 98.5 per cent. of pure soft copper by the standard adopted by the American Institute of Electrical Engineers," be changed to read, "Each of the individual wires shall have a resistivity of not more than 888.55 ohms (mile, pound) at 20 deg. C."

This resistivity corresponds to 98.5 per cent. of the conductivity of the new Annealed Copper Standard.

The Committee recommends no further revisions of these specifications.

REVISION OF SPECIFICATIONS FOR OVERHEAD CROSSINGS OF ELECTRIC LIGHT AND POWER TRANSMISSION LINES

At the 1911 Convention, the Committee on Power Distribution submitted specifications on this subject, recommending that they be adopted by the Association as "Standard" (pages 86, 142, 1911 Proceedings). The specifications were approved by the Association and referred to the Committee on Standards for adoption as "Standard" (page 164, 1911 Proceedings).

At a subsequent meeting of the Committee on Standards, Mr. Katté, a member of the Committee and also a member of the Committee on Electricity of the American Railway Engineering Association, stated that in his opinion the specifications in their present shape would not be approved by the last-named Committee.

A number of criticisms were made and revisions suggested, but the specifications as they stood were finally approved with but one dissenting vote, for adoption as "Standard" and the matter therefore went to the letter ballot of the member companies of the Association.

Before the ballots were submitted, however, a strenuous protest against the adoption of the specifications as "Standard" was received from Mr. E. H. Davis, General Manager of the Williamsport Railway Company, Williamsport, Pa.

In consequence of this, the Chairman, Vice-Chairman, Secretary Donecker of the American Association and Secretary-Treasurer Litchfield of this Association, met Mr. Davis in New York on January 25, and gave an exhaustive hearing to the points which he raised against the adoption of the specifications.

We also had before us, a memorandum of the action of the Executive Committee of the National Electric Light Association, on a resolution presented by a special Committee of that Association, to which was referred the report of their Overhead Line Construction Committee, recommending the adoption of these specifications as Standard.

The Pennsylvania Electric Association had also previously registered objections to the adoption of these specifications. In effect, the resolution of the Executive Committee of the National Electric Light Association recommended the use in general of the specifications as Recommended Practice rather than as Standard.

In view of the conditions above set forth, the Chairman wrote Secretary-Treasurer Litchfield on January 12, stating that conditions had arisen since the specifications were passed to the Committee on Standards, showing the need of further consideration of this matter by the Committee, and suggested that it be recommended to the Executive Committee of the American Electric Railway Association that the letter ballot be postponed, and that the specifications be referred back to the Committee on Power Distribution for further consideration.

The Committee felt at that time that it was extremely important that these specifications should not be adopted by the Association as "Standard" until it had definite knowledge that it had been so adopted by the Steam Railroad representatives, and that no vital interest would be sacrificed by the suggested postponement of the ballot.

Mr. Litchfield thereupon consulted President Ackerman, and the matter was referred to the Executive Committee of the American Electric Railway Association, with the result that these specifications were withheld from the letter ballot, and the matter was referred back to this Committee for further consideration.

The above mentioned action of the Executive Committee of the National Electric Light Association was taken only after the matter had been carefully considered by its General Counsel and the resolution which it passed in relation to the report of the Committee on Overhead Line Construction, of which these specifications were a part, is as follows: "That the Executive Committee commend the able and exhaustive report of the Committee on Overhead Line Construction, submitted at the last Convention of the Association, to the favorable consideration of the member companies. It sets out with great clearness and particularity, a high standard of practice, which, in the opinion of this Committee, should be regarded as a standard toward which all companies should strive.

"Local conditions or special considerations may, however, in particular cases, make the adoption of the recommendations of the report in whole or in part impracticable or inadvisable, and non-compliance therewith in such cases would not necessarily be bad practice.

"Upon the whole, however, we consider the report as embodying the best standard of overhead line construction which has been suggested, and endorse it with the qualifications hereinbefore set forth."

The Committee feels that action on this matter should only be taken after careful consideration by the Executive Committee of the American Electric Railway Association with respect to the legal aspects of the case and its relation to Municipalities and Public Service Commissions, if the Association should adopt these specifications as Recommended Practice or as Standard.

In its report to the Committee on Standards, the Committee recommended the following revision of these specifications as printed in the 1911 Proceedings, and that it be given more time to investigate:

Page 112, the following paragraph,

"1. *Scope:* These specifications shall apply to overhead electric light and power line crossings (except trolley contact wires) over railroad right of way, tracks or lines of wires; and further these specifications shall apply to overhead electric light and power wires of over 5,000 volts constant potential, crossing, or construction over telephone, telegraph or other similar lines."

To read,

1. *Scope:* These specifications shall apply to Overhead Electric Light and Power Line Crossings (except trolley contact wires) over railroad right of way, tracks, or lines of wires.

Page 113, the following paragraph, under "Location,"

"5. The poles, or towers, supporting the crossing span, and the adjoining span on each side, preferably shall be in a straight line."

To read,

5. The poles, or towers, supporting the crossing span and the adjoining span on each side, preferably shall be in a straight line, and of such height that there shall be no lifting strain upon the supporting insulators.

On July 18, the Committee was informed by Mr. Farley Osgood, Chairman of the Joint Committee of the various interests that had considered this subject, that on May 15, 1912, the American Railway Association presented a report, through its Committee on Electrical Working, in which was included these specifications in complete detail, and the same were approved at the Convention and adopted by that Association as Recommended Practice.

This action was taken, however, after a revision of the specifications, which had not been considered by the Committee.

Your Committee therefore now recommends that these specifications, as revised by it, be adopted by the Association as "Recommended Practice," and that it be authorized to confer with the other parties in interest with a view to securing united action on the revision proposed by the Committee and the other interests.

SPECIFICATIONS FOR TROLLEY WIRE

At the 1911 Convention, the Committee submitted specifications for 00 Round Hard-Drawn Copper Trolley Wire, which were approved by the Association and passed to the Committee on Standards (Pages 86, 160–161, 1911 Proceedings).

At the meeting of that Committee shortly after the 1911 Convention, the specifications were approved for submission to letter ballot of the Member Companies for adoption as Standard.

For the purpose of harmonizing, if possible, these specifications and the specifications for Hard-Drawn Copper Wire of the American

Society for Testing Materials, as referred to in the opening of this report, the Chairman appointed Messrs. Richey, Harte and C. F. Woods as a Subcommittee to meet Messrs. Capp, Bassett and Tinsley, a Subcommittee of the American Society for Testing Materials. Meetings of the joint Subcommittee were held in New York, February 24 (present, Messrs. Richey, Corning, Harte, Bassett, Gray, Tinsley and Capp), and May 22 (present Messrs. Palmer, Richey, Woods, Capp and Bassett).

The most important difference between the specifications of the respective Associations had been in relation to the inclusion of a torsion test. Representatives of the American Society for Testing Materials had previously claimed that the torsion test was worthless, in that it was not in any manner a gauge of the performance of the material, that it had long since been abandoned by the American Telephone & Telegraph Company as a test for hard-drawn copper wire, and that it would not disclose any faults or defects which would not be disclosed by the other tests prescribed in their specifications.

On the other hand, the Committee on Power Distribution was certain, from the experience of its members and that of other member companies, that the torsion test was distinctly a gauge of the uniform condition of the material, that it would and did disclose seams and other defects which would not otherwise be shown, and therefore included the torsion test in the Committee's specifications.

They believed that the performance required of and the usage given the trolley wire differed so materially from that of the wire used for ordinary suspension and conducting purposes, that it required a different material and one which would pass a more stringent test than that ordinarily used in connection with hard-drawn copper wire.

At the joint meeting, the representatives of the American Society for Testing Materials stated that they were now prepared to admit that the torsion test would disclose defects which would not be disclosed in any other manner, nor by the tests prescribed in their specifications, but questioned whether the number of turns prescribed by the torsion test of the Committee's specifications were not greater than the number required.

In discussion which followed, no agreement was reached as to the number of turns which should be prescribed and it was arranged that a subsequent meeting should be held to determine upon the nature of a series of tests to be made by the joint Subcommittees, for the purpose of determining the necessity of modifying the number of turns prescribed by the Committee's specifications.

The subsequent meeting of the joint Subcommittees was held in New York on July 19; present Messrs. Woods and Richey of the Committee and Messrs. Bassett and Tinsley of the Subcommittee of the American Society for Testing Materials. At this meeting there was outlined the procedure to be taken in the further investigation of this subject.

The Committee at this time therefore recommends no revision of these specifications.

STANDARD SECTIONS OF GROOVED TROLLEY WIRE

A Section of 0000 Grooved Trolley Wire was approved as "Standard" at the 1909 Convention (pages 359, 398, 1909 Proceedings). Sections of 00 and 000 sizes were approved at the 1911 Convention and passed to the Committee on Standards (pages 90, 160, 1911 Proceedings).

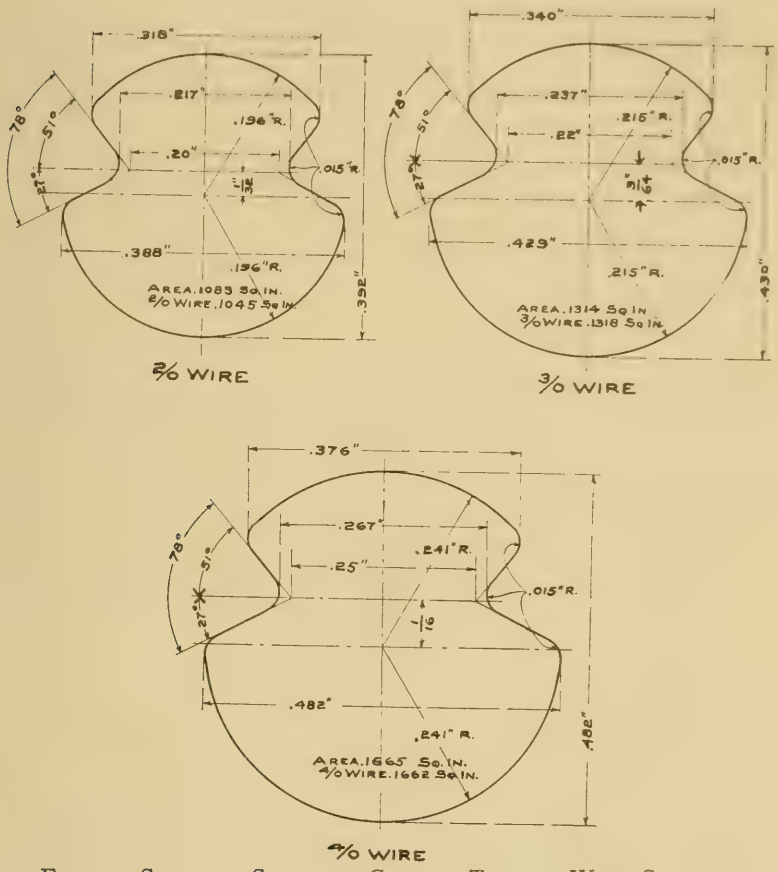

FIG. 1.—SHOWING STANDARD GROOVED TROLLEY WIRE SECTIONS.

At the subsequent meeting of the Committee on Standards these sections were approved for submission to letter ballot of the Member Companies, for adoption as "Standard."

Since the Convention, it has transpired that the drawings showing the sections have been interpreted by different parties in different ways, and a discussion as to their interpretation has arisen between the manufacturers of copper wire represented on the Committee of the American Society for Testing Materials.

It appears that varying interpretations by the different manufacturers has resulted in placing on the market slightly differing sections of trolley wire, each being claimed to be in accordance with the Association Standard.

The Committee realizes that the drawings submitted in previous reports were too small to allow a definite and uniform interpretation of the same, and in its report to the Committee on Standards has therefore recommended that the present Standard drawings be revised, as shown by the drawing submitted herewith.

The American Society for Testing Materials, which had adopted the Sections as shown in the Committee's previous reports, stands ready we are informed, to follow our interpretation of these drawings.

In the Sections as shown in this report, no change has been made from the Sections intended to be shown by the drawings in the previous reports quoted.

STANDARD LINE MATERIAL AND CONSTRUCTION

The Committee is pursuing its investigation of this subject, with a view to later submitting definite Standard specifications, covering the various kinds of materials and construction generally used.

The matter is in the hands of a Subcommittee; Messrs. Harte, Cadle and Hayden. The Committee regrets that it cannot report more fully on this subject at this time, although a great amount of work has been done and the matter is well in hand.

It submits, however, as an indication of progress in this direction, the following: Specifications for Galvanizing on Iron and Steel (see Appendix D), which it recommends for adoption by the Association as "Standard." These specifications are practically the same as those included in the Specifications for High Tension Overhead Crossings already acted on by the Association and which, it will be remembered, were included in the joint report of the Committee on Overhead Line Construction of the National Electric Light Association, the High Tension Committee of the American Institute of Electrical Engineers, the Committee on Power Distribution of the American Electric Railway Engineering Association, the Committee on High Tension Wire Crossings of the Association of Railway Telegraph Superintendents, and the Subcommittee of the Committee on Electricity of the American Railway Engineering Association.

The Committee includes in Appendix E as a part of its report several specifications that have been in successful use for the purchase of material.

They are herewith submitted for constructive criticism and comment, with a view to their submission next year in such revised form as may be necessary to enable the Committee to recommend them for adoption as "Standards."

Any comment or criticism will be welcomed by the Committee and it further earnestly requests that they be submitted in writing not later than January 1, 1913.

ELECTRIC WIRE AND CABLE TERMINOLOGY

At the request of the Executive Committee the Power Distribution Committee submitted certain definitions of "strand" and "cable" to the 1911 Convention (pages 110, 111, 1911 Proceedings). The Committee stated at that time that the matter was under consideration by the Standards Committee of the American Institute of Electrical Engineers and suggested taking no further action at the time.

This subject has since been considered by the Standards Committee of the Institute and at their request the United States Bureau of Standards has prepared a proposed standard electric wire and cable terminology believed to represent the weight of current practice. The Bureau has requested the comments and suggestions of our Committee on Standards and has been informed that the matter has been referred to the Committee on Power Distribution.

The definitions prepared by the Bureau of Standards are recommended although not yet adopted by the Standards Committee of the American Institute of Electrical Engineers.

The Committee, in its report to the Committee on Standards, has recommended that the electric wire and cable Terminology appearing in Apendix F of this report be adopted by the Association as "Standard," and that the United States Bureau of Standards and the Standards Committee of the American Institute of Electrical Engineers be notified of such action.

Respectfully submitted,

G. W. Palmer, Jr., *Chairman.*
A. S. Richey, *Vice-Chairman.*
Gaylord Thompson
Chas. R. Harte
L. C. Cadle
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Wm. Roberts
J. H. Barnard
John W. Corning
Committee on Power Distribution.

APPENDIX A

SPECIFICATIONS FOR OVERHEAD CROSSINGS OF TROLLEY CONTACT WIRES OVER RAILWAY TRACKS

General Requirements

1. *Scope:* These specifications shall apply to overhead trolley contact wire crossings over railroad tracks.

2. *Location:* The poles, or towers, supporting the crossing shall preferably be outside the railroad company's right of way.

3. Unusually long crossings or adjoining spans shall be avoided wherever possible.

4. The poles, or towers, shall be located as far as practicable from inflammable materials or structures.

5. Trolley guards should not be used except possibly in unusual cases due to complicated alignment of the crossing track.

6. *Clearance:* The side clearance of poles supporting the trolley wires shall not be less than twelve feet (12 ft. 0 in.) from the nearest rail of the main railroad track, nor less than six feet (6 ft. 0 in.) from the nearest rail of railroad sidings, unless the former distance is greater than existing clearances from the rail or involves unusually long spans: but in no case shall the clearance be less than six feet (6 ft. 0 in.). At loading sidings sufficient space shall be left for a driveway.

7. The clear head room shall not be less than twenty-one feet (21 ft. 0 in.) above the top of rail under the most unfavorable conditions of temperature and loading, and the height of trolley wire above top of rail shall be as nearly as possible uniform for at least one hundred feet (100 ft. 0 in.) on either side of the crossing span.

8. Catenary construction for crossing and adjoining spans shall be used when the difference in height of trolley wire above top of rail between the middle of such spans and the points of support of same, with ordinary construction, would exceed twelve inches (0 ft. 12 in.) in a 100-foot span, or a proportionate difference for spans of other lengths.

9. *Conductors:* The normal mechanical tension in trolley wires shall generally be the same in the crossing span and in the adjoining span on each side. This shall also apply to the suspension cable in catenary construction.

10. Neither the trolley wire nor its supporting wires shall be spliced in the crossing span nor between the points of anchorage on either side.

11. *Temperature:* In the computation of stresses and clearances, and in erection, provision shall be made for a variation in temperature

from —20 deg. to +120 deg. Fahr. A suitable modification in temperature requirements shall be made for regions in which the above limits would not fairly represent the extreme range of temperature.

12. For span construction the poles adjacent to the crossing shall be guyed away from the trolley wire when practicable.

13. The trolley wire shall be anchored in both directions at the third pole on each side of the crossing, except where impracticable on account of adjoining curves, and all anchored poles shall be guyed back.

14. At each end of the crossing span the suspension from the pole, or bracket, shall be in duplicate, each suspension to be of sufficient strength to sustain the maximum loading.

15. *Inspection:* If required by contract between the crossing companies, all material and workmanship shall be subject to the inspection of the company crossed, provided that reasonable notice of the intention to make inspection shall be given such company. Defective material shall be rejected, or shall be removed and replaced with suitable material.

16. *Drawings:* If required by contract between the crossing companies, ———— (————) complete sets of general and detail drawings shall be furnished for approval, before any construction is commenced.

Loads

17. The conductors shall be considered as uniformly loaded throughout their length, with a load equal to the resultant of the dead load, plus the weight of a layer of ice one-half inch (½ in.) in thickness, and a wind pressure of 8.0 lb. per square foot on the ice-covered diameter, at a temperature of 0 deg. Fahr.

18. The weight of ice shall be assumed at 57 lb. per cu. ft. (0.033 lb. per cu. in.).

19. Insulators and attachments shall be designed to withstand, with the designed factor of safety, the weight and tension of the trolley contact and supporting wires, or cables, under the maximum loading.

20. The poles, or towers, and the setting thereof, shall be designed to withstand, with the designated factor of safety, the combined stresses from their own weight, the wind pressure on the pole or tower, and the above wire loading on the crossing spans and the next adjoining span on either side. The wind pressure on the poles or towers shall be assumed at 13 lb. per sq. ft. on the projected area of solid or closed structures, and on one and one-half (1½) times the projected area of latticed structures.

21. The poles shall be designed to withstand loads specified in paragraph 20, joined with the unbalanced tension of broken trolley wires.

22. The poles may be permitted reasonable deflection under the specified loading, provided that such deflection does not reduce the head room below the requirements of Paragraph 7, or produce stresses in excess of those specified in Paragraphs 53–56, inclusive.

23. The minimum depth of pole setting shall be six feet (6 ft. 0 in.).

Factors of Safety

24. The ultimate unit stress divided by the allowable unit stress shall not be less than the following:

Trolley wire	2
Other wires and cables (except guys)	2
Insulators, conductor attachments, guys	3
Wooden poles and crossarms	6
Structural steel	3
Reinforced concrete poles and crossarms	4
Foundations	2

Note: The use of treated poles and crossarms is recommended. The treatment of wooden poles and crossarms covers thorough impregnation with preservative by either closed or open tank process. The treatment of poles need not extend higher than a point two (2) feet above the ground line.

25. *Insulators:* Insulators shall not flash over at four times the normal working voltage, under a precipitation of water of one-fifth of an inch (⅕ in.) per minute at an inclination of 45 deg. to the axis of the insulator.

Material

26. The trolley contact wire shall be of hard-drawn copper, or other material not easily abraded.

27. The minimum size of trolley contact wire shall be No. 00 B. & S. gauge.

28. Strain insulators shall be so constructed that the wires holding the insulators in position will interlock in case of failure of the insulator.

29. Span wires shall be galvanized, or copper-covered stranded steel, or bronze cables, not less than five-sixteenths inch (5/16 in.) in diameter.

30. *Guys:* Guys shall be galvanized or copper-covered stranded steel, or bronze cable, not less than one-fourth inch (¼ in.) in diameter, or galvanized rolled rods of equivalent tensile strength.

31. Guys to the ground shall connect to a galvanized anchor rod, extending at least one foot above the ground level.

32. The detail of the anchorage shall be definitely shown upon the plans.

33. *Poles:* Wooden poles shall be of selected timber, peeled, free from defects which would decrease their strength or durability, not less than seven inches (0 ft. 7 in.) minimum diameter at the top, or twelve inches (0 ft. 12 in.) at six feet from the butt.

34. Tubular poles shall be of wrought-iron or steel pipe, the minimum size of which shall be, for two-section poles, standard weight five and six-inch pipe, and for three-section poles, four, five and six-inch pipe.

NOTE: The use of protective sleeves at the ground line is recommended.

35. *Concrete:* All concrete and concrete material shall be in accordance with the requirements of the Specifications for Concrete and Reinforced Concrete.

STRUCTURAL STEEL

36. Structural steel shall be in accordance with the Manufacturer's Standard Specifications.

37. The design and workmanship shall be strictly in accordance with first-class practice.

38. The form of the frame shall be such that the stresses may be computed with reasonable accuracy, or the strength shall be determined by actual test.

39. The sections used shall permit inspection, cleaning and painting, and shall be free from pockets in which water or dirt can collect.

40. The length of a main compression member shall not exceed 180 times its least radius of gyration.

41. The minimum thickness of metal in galvanized structures shall be one-quarter inch (¼ in.) for main members and one-eighth inch (⅛ in.) for secondary members. The minimum thickness of painted material shall be one-quarter inch (¼ in.).

PROTECTIVE COATINGS

42. All structural steel shall be thoroughly cleaned at the shop and be galvanized, or given one coat of approved paint.

43. *Painting:* All contact surfaces shall be given one (1) coat of paint before assembling.

44. All painted structural steel shall be given two (2) field coats of an approved paint.

45. The surface of the metal shall be thoroughly cleaned of all dirt, grease, scale, etc., before painting, and no painting shall be done in freezing or rainy weather.

46. *Galvanizing:* Galvanized material shall be in accordance with the Standard Specifications for Galvenizing on Iron and Steel.

47. Bolt holes in galvanized material shall be made before galvanizing.

Foundations

48. The foundations for steel poles and towers shall be designed to prevent overturning. The weight of concrete shall be assumed as 140 lb. per cu. ft. In good ground, the weight of "earth" (calculated 30 deg. from the vertical), shall be assumed as 100 lb. per cu. ft. In swampy ground, special measures shall be taken to prevent uplift or depression.

49. The top of the concrete foundation, or casing, shall not be less than six inches (6 in.) above the surface of the ground, nor less than one foot (1 ft.) above extreme high water.

50. When located in swampy ground, wooden crossing and next adjoining poles shall be set in barrels of broken stone or gravel, or in broken stone or timber footings.

51. When located in the sides of banks, or when subject to washouts, foundations shall be given additional depth, or be protected by cribbing or riprap.

52. All foundations and pole settings shall be tamped in six-inch (6 in.) layers, while back filling.

Working Unit Stresses

Obtained by dividing the ultimate breaking strength by the factors of safety given in Paragraph 24.

53. *Structural Steel:*

Shear	14,000	lb. per sq. in.
Tension (net section)	18,000	" " " "
Compression	$18{,}000 - 60\frac{1}{r}$	" " " "

54. *Rivets, Pins:*

Shear	10,000	lb. per sq. in.
Bearing	20,000	" " " "
Bending	20,000	" " " "

55. *Bolts:*

Shear	8,500	lb. per sq. in.
Bearing	17,000	" " " "
Bending	17,000	" " " "

56. *Wire:*

Copper, hard-drawn, solid, B. & S. gauge, Nos. 0000, 000, 00 — 25,000 lbs. per sq. in.

57. *Timber:*	Bending	Compression
Eastern White Cedar	600 lb. per sq. in.	$600\left(1-\frac{L}{60D}\right)$
Chestnut	850 " " " "	850 "
Washington Cedar	850 " " " "	850 "
Idaho Cedar	850 " " " "	850 "
Port Orford Cedar	1150 " " " "	1150 "
Long Leaf Yellow Pine....	1100 " " " "	1100 "
Short Leaf Yellow Pine....	950 " " " "	950 "
Douglas Fir	1000 " " " "	1000 "
White Oak	950 " " " "	950 "
Red Cedar	700 " " " "	700 "
Bald Cypress (Heartwood).	800 " " " "	800 "
Redwood	850 " " " "	850 "
Catalpa	500 " " " "	500 "
Juniper	550 " " " "	550 "

L = Length in inches.
D = Least, side, or diameter, in inches.

APPENDIX B

SPECIFICATIONS FOR OVERHEAD CROSSINGS OF FOREIGN WIRES WITH ELECTRIC RAILWAY WIRES

General Requirements

1. *Scope:* These specifications shall apply to crossings of electric light, power, telephone, telegraph, and other similar lines over electric railway right-of-way and tracks or lines of wires thereon.

2. *Locations:* The poles, or towers, supporting the crossing shall preferably be outside the Electric Railway Company's right-of-way.

3. Unusually long crossing spans shall be avoided wherever practicable.

4. The poles, or towers, shall be located as far as practicable from inflammable materials or structures.

5. The poles, or towers, supporting the crossing span and the adjoining span on each side, preferably, shall be in a straight line.

6. The crossing wires, or cables, shall cross **over** low tension feed wires, telegraph, telephone, signal and similar wires, but **under** high tension power transmission wires, wherever practicable; except that, when the voltage of crossing wires is higher than that of the Electric Railway Company's high tension wires, such crossing wires should cross **over** all wires of the Electric Railway Company.

7. Cradles, or overhead bridges, shall not be used.

8. *Clearance:* The side clearance of poles supporting the crossing wires shall be not less than twelve feet (12 ft. 0 in.) from the nearest rail of the main track, not less than six feet (6 ft. 0 in.) from the nearest rail of sidings, unless the former distance is greater than existing clearances from the rail or involves unusually long spans: but in no case shall the clearance be less than six feet (6 ft. 0 in.). At loading sidings sufficient space shall be left for a driveway.

9. The clear headroom of crossing wires shall not be less than thirty feet (30 ft. 0 in.) above the top of the rail under the most unfavorable conditions of temperature and loading, except that a single pair of service wires at a potential not exceeding 750 volts may be carried at minimum headroom of twenty-four feet (24 ft. 0 in.).

10. Clearance between crossing circuits, either of which exceeds 750 volts, under the most unfavorable conditions of temperature and loading shall not be less than eight feet (8 ft. 0 in.), where possible. For circuits not exceeding 750 volts, the clearance between crossing wires may be two feet (2 ft. 0 in.) with insulated wires and four feet (4 ft. 0 in.) with bare wires.

11. The separation of conductors carrying alternating current,

supported by pin insulators for spans not exceeding 150 feet shall not be less than:

Line voltage								Separation
Not exceeding	6600	volts	.	.	.	.	.	14½ in.
Exceeding	6600	"	but not exceeding			14000	...	24 "
"	14000	"	"	"	"	27000	...	30 "
"	27000	"	"	"	"	35000	...	36 "
"	35000	"	"	"	"	47000	...	45 "
"	47000	"	"	"	"	70000	...	60 "

NOTE: Fo spans exceeding 150 feet, the pin spacing should be increased, depending upon the length of the span and the sag of the conductors.

With constant potential direct current circuits, not exceeding 750 volts, the minimum spacing shall be ten (10) inches.

NOTE: This requirement does not apply to wires of the same phase or polarity between which there is no difference of potential.

12. When supported by insulators of the disc or suspension type, the crossing span and the next adjoining spans shall be dead-ended at the poles or towers supporting the crossing spans, so that at these poles or towers, these insulators shall be used as strain insulators.

The clearance in any direction between the conductors nearest the pole or tower, and the pole or tower, shall not be less than:

Line voltage								Clearances
Not exceeding	14000	.	.	.	.	.	.	9 in.
Exceeding	14000	but not exceeding			27000	.....		15 "
"	27000	"	"	"	35000	.....		18 "
"	35000	"	"	"	47000	.....		21 "
"	47000	"	"	"	70000	.....		24 "

13. *Conductors:* The normal mechanical tension in the conductors shall generally be the same in the crossing span and in the adjoining span on each side and the difference in length of the crossing and adjoining spans shall generally be not more than 50 per cent. of the length of the crossing span.

14. The conductors shall not be spliced in the crossing span or in the adjoining span on either side.

15. The method of attaching the conductors to the poles or towers shall be such as to hold the wires under maximum loading to the supporting structures, in case of shattered insulators, or wires broken or burned at the insulator, without allowing an amount of slip which would materially reduce the clearance specified in Paragraphs 10 and 11.

16. *Guys:* Wooden poles supporting the crossing span shall be side guyed in both directions, if practicable, and be head guyed in both directions. Braces may be used instead of guys.

Strain insulators shall be used in guys from wooden poles carrying any power wire of less than 6600 volts. Strain insulators shall not be used in guying steel structure, nor required on wooden poles carrying wires all of which are 6600 volts or more.

17. *Signs:* If required by the Electric Railway Company, warning signs of an approved design shall be placed on all poles and towers located on the Electric Railway Company's right-of-way.

18. *Grounding:* For voltages over 5000 volts, wooden crossarms, if used, shall be provided with a grounded metallic plate on top of the arm, which shall be not less than ⅛ in. in thickness and have a sectional area and conductivity not less than that of the line conductor. Metal pins shall be electrically connected to this ground. Metal poles and metal arms on wooden poles shall be grounded.

19. The electrical conductivity of the ground conductor shall be adjusted to the short circuit capacity of the system and shall not be less than that of a No. 4 B. & S. gauge copper wire.

20. *Temperature:* In the computation of stresses and clearances, and in erection, provision shall be made for a variation in temperature from —20 deg. to +120 deg. Fahr. A suitable modification in the temperature requirements shall be made for regions in which the above limits would not fairly represent the extreme range of temperature.

21. *Inspection:* If required by contract between the crossing companies all material and workmanship shall be subject to the inspection of the company crossed, provided that reasonable notice of the intention to make inspection shall be given by such company. Defective material shall be rejected, or shall be removed and replaced with suitable material.

22. *Drawings:* If required by contract between the crossing companies ——— (——) complete sets of general and detail drawings shall be furnished for approval, before any construction is commenced.

Loads

23. The conductors shall be considered as uniformly loaded throughout their length, with a load equal to the resultant of the dead load, plus the weight of a layer of ice one-half inch (½ in.) in thickness, and a wind pressure of 8.0 lb. per sq. ft. on the ice covered diameter, at a temperature of 0 deg. Fahr.

24. The weight of ice shall be assumed at 57 lb. per cu. ft. (0.033 lb. per cu. in.)

25. Insulators, pins and conductor attachments shall be designed to withstand, with the designated factor of safety, the tension in the conductors, under the maximum loading.

26. The poles, or towers, and the setting thereof, shall be designed to withstand, with the designated factor of safety, the combined stresses from their own weight, the wind pressure on the pole or tower, and

the above wire loading on the crossing spans and the next adjoining span on either side. The wind pressure on the poles or towers shall be assumed at 13 lb. per sq. ft. on the projected area of solid or closed structures, and on one and one-half (1½) times the projected area of latticed structures.

27. The poles, or towers, shall also be designed to withstand the loads specified in Paragraph 26, combined with the unbalanced tension of:

2	broken wires for poles, or towers, carrying	5 wires or less.
3	" " " " " " "	6 to 10 wires.
4	" " " " " " "	11 or more wires.

Crossarms shall be designed to withstand the loading specified in Paragraph 26, combined with the unbalanced tension of one wire broken at the pin farthest from the pole.

28. The poles, or towers, may be permitted a reasonable deflection under the specified loading, provided that such deflection does not reduce the clearances specified in Paragraph 10 more than 25 per cent, or produce stresses in excess of those specified in Paragraphs 66 to 69 inclusive.

29. The minimum depth of pole setting shall be six feet (6 ft.).

Factors of Safety

30. The ultimate unit stress divided by the allowable unit stress shall not be less than the following:

Wires and cables	2
Pins	2
Insulators, conductor attachments, guys	3
Wooden poles and crossarms (untreated)	6
Structural steel	3
Reinforced concrete poles and crossarms	4
Foundations	2

Note: The use of treated poles and crossarms is recommended. The treatment of wooden poles and crossarms covers thorough impregnation with preservatives by either closed or open tank process. Treatment of poles need not extend higher than a point two feet (2 ft.) above the ground line.

31. *Insulators:* Insulators for line voltages of less than 9000 shall not flash over at four times the normal working voltage, under a precipitation of water of one-fifth of an inch (1/5 in.) per minute at an inclination of 45 deg. to the axis of the insulator.

32. Each separate part of a built up insulator for line voltages over 9000 shall be subjected to the dry flash-over test of that part for five consecutive minutes.

33. Each assembled and cemented insulator shall be subjected to its dry flash-over test for five consecutive minutes.

34. The dry flash-over test shall not be less than:

Line Voltage					Test Voltage
Exceeding	9000	but not exceeding	14000	.....	65000
"	14000	" " "	27000	.....	100000
"	27000	" " "	35000	.....	125000
"	35000	" " "	47000	.....	150000
"	47000	" " "	60000	.....	180000
"	60000	" " "	.....	3 times line voltage	

35. Each assembled insulator shall be subjected to a wet flash-over test under a precipitation of water of one-fifth of an inch (1/5 in.) per minute, at an inclination of 45 deg. to the axis of the insulator.

The wet flash-over test shall not be less than:

Line Voltage					Test Voltage
Exceeding	9000	but not exceeding	14000	.....	40000
"	14000	" " "	27000	.....	60000
"	27000	" " "	35000	.....	80000
"	35000	" " "	47000	.....	100000
"	47000	" " "	60000	.....	120000
"	60000	" " "	.....	Twice line voltage	

36. Test voltages above 35000 volts shall be determined by the A. I. E. E. Standard Spark Gap method.

37. Test voltages below 35000 volts shall be determined by transformer ratio.

MATERIAL

38. The conductors shall be of copper, aluminum or other non-corrodible material, except that in exceptionally long spans where the required mechanical strength cannot be obtained with the above materials, galvanized or copper covered steel strand may be used.

39. For voltages not exceeding 750 volts, solid or stranded conductors may be used up to and including 0000 in size; above 0000 in size, stranded conductors shall be used. For voltages exceeding 750 volts, and not exceeding 5000 volts, solid or stranded conductors may be used up to and including 00 in size; above 00 in size, conductors shall be stranded. For voltages exceeding 5000 volts, all conductors shall be stranded. Aluminum conductors for all voltages and sizes shall be stranded.

The minimum size of conductors shall be as follows:

No. 6 B. & S. gauge copper, for voltages not exceeding 5000 volts.
" 4 " " " " " " " exceeding 5000 "
" 1 " " " " aluminum for all voltages.

40. *Insulators:* Insulators shall be of porcelain for voltages exceeding 5000 volts.

41. Strain insulators for guys shall have an ultimate strength of not less than twice that of the guy in which they are placed. Strain

insulators shall be so constructed that the guy wires holding the insulators in position will interlock in case of the failure of the insulator.

Strain insulators shall not flash over at four times the maximum line voltage under a precipitation of water of one-fifth of an inch (⅕ in.) per minute, at an inclination of 45 deg. at the axis of the insulator.

42. *Pins:* For voltages of 5000 or over, insulator pins shall be of steel, wrought iron, malleable iron, or other approved metal or alloy, and shall be galvanized, or otherwise protected from corrosion.

43. *Guys:* Guys shall be galvanized or copper covered stranded steel, or bronze cable, not less than 5/16 in. in diameter, or galvanized rolled rods of equivalent tensile strength.

44. Guys to the ground shall connect to a galvanized anchor rod, extending at least one foot above the ground level.

45. The detail of the anchorage shall be definitely shown upon the plans.

46. *Poles:* Wooden poles shall be of selected timber, peeled, free from defects which would decrease their strength or durability, not less than seven inches (7 in.) minimum diameter at the top, or twelve inches (12 in.) at six feet from the butt.

47. Tubular poles shall be of wrought iron or steel pipe, the minimum size of which shall be, for two-section poles, standard weight five and six inch pipe, and for three-section poles, four, five and six inch pipe.

NOTE: The use of protective sleeves at the ground line is recommended.

48. *Concrete:* All concrete and concrete material shall be in accordance with the requirements of the specifications for Concrete and Reinforced Concrete.

STRUCTURAL STEEL

49. Structural steel shall be in accordance with the Manufacturer's Standard Specification.

50. The design and workmanship shall be strictly in accordance with first-class practice.

51. The form of the frame shall be such that the stresses may be computed with reasonable accuracy, or the strength shall be determined by actual test.

52. The sections used shall permit inspection, cleaning and painting, and shall be free from pockets in which water or dirt can collect.

53. The length of a main compression member shall not exceed 180 times its least radius of gyration. The length of a secondary compression member shall not exceed 220 times its least radius of gyration.

54. The minimum thickness of metal in galvanized structures shall be one-quarter inch (¼ in.) for main members and one-eighth inch (⅛ in.) for secondary members. The minimum thickness of painted materials shall be one-quarter inch (¼ in.).

Protective Coatings

55. All structural steel shall be thoroughly cleaned at the shop and be galvanized, or given one coat of approved paint.

56. *Painting:* All contact surfaces shall be given one (1) coat of paint before assembling.

57. All painted structural steel shall be given two (2) field coats of approved paint.

58. The surface of the metal shall be thoroughly cleaned of all dirt, grease, scale, etc., before painting, and no painting shall be done in freezing or rainy weather.

59. *Galvanizing:* Galvanized material shall be in accordance with the Standard Specifications for Galvanizing Iron and Steel.

60. Bolt holes in galvanized material shall be made before galvanizing.

Foundations

61. The foundations for steel poles and towers shall be designed to prevent overturning.

The weight of concrete shall be assumed at 140 lb. per cu. ft. In good ground, the weight of "earth" (calculated at 30 deg. from the vertical) shall be assumed at 100 lb. per cu. ft. In swampy ground, special measure shall be taken to prevent uplift or depression.

62. The top of the concrete foundation, or casing, shall not be less than six inches (6 in.) above the surface of the ground, nor less than one foot (1 ft.) above extreme high water.

63. When located in swampy ground, wooden crossing and next adjoining poles shall be set in barrels of broken stone or gravel, or in broken stone or timber footings.

64. When located in the sides of banks, or when subject to washouts, foundations shall be given additional depth, or be protected by cribbing or riprap.

65. All foundations and pole settings shall be tamped in six inch (6 in.) layers, while back filling.

Working Unit Stresses

Obtained by dividing the ultimate breaking strength by the factors of safety given in Paragraph 30.

66. *Structural Steel:*

Tension (net section)	18000	lb. per sq. in.
Shear	14000	" " " "
Compression	$18000-60\frac{1}{r}$	" " " "

67. *Rivets, Pins:*

Shear	10000	" " " "
Bearing	20000	" " " "
Bending	20000	" " " "

68. *Bolts:*

Shear	8500	lb. per sq. in.
Bearing	17000	" " " "
Bending	17000	" " " "

69. *Wire and Cables:*

Copper, hard-drawn,	solid,	B. & S. gauge,				0000, 000, 00	25,000 lb. per sq. in.
"	"	"	"	"	"	0	27,500 " " " "
"	"	"	"	"	"	No. 1	28,500 " " " "
"	"	"	"	"	"	No. 2, 4, 6	30,000 " " " "
"	soft	"	"	"	"		17,000 " " " "
"	hard	"	stranded	"	"		30,000 " " " "
"	soft	"	"	"	"		17,000 " " " "
Aluminum,	hard	"	"	"	"	gauge under 000	12,000 " " " "
"	"	"	"	"	"	" 0000 and over	11,500 " " " "

70. *Untreated Timber:*

	Bending	Compression
Eastern White Cedar	600 lbs. per sq. in.	$600\left(1-\frac{L}{90D}\right)$
Chestnut	850 " " " "	850 "
Washington Cedar	850 " " " "	850 "
Idaho Cedar	850 " " " "	850 "
Port Orford Cedar	1150 " " " "	1150 "
Long Leaf Yellow Pine	1100 " " " "	1100 "
Short Leaf Yellow Pine	950 " " " "	950 "
Douglas Fir	1000 " " " "	1000 "
White Oak	950 " " " "	950 "
Red Cedar	700 " " " "	700 "
Bald Cypress (Heart-wood)	800 " " " "	800 "
Redwood	850 " " " "	850 "
Catalpa	500 " " " "	500 "
Juniper	550 " " " "	550 "

L = Length in inches.
D = Least side, or diameter, in inches.

REFERENCES 1911 PROCEEDINGS

Committee Report Appendix A — Wind and Ice Loads, pp. 121–123.
" " " B — Tables and Curves of Conductor Sags, pp. 124–130.

APPENDIX C

TABLE I (Part 1)

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER

American Wire Gauge (B. & S.). **English Units**

Gauge No.	Diameter in mils	Cross-Section		Ohms per 1000 Feet						No.
		Circular mils	Square inches	0° C (=32° F)	15° C (=59° F)	20° C (=68° F)	25° C (=77° F)	50° C (=122° F)	75° C (=167° F)	
0000	460.0	211 600.	0.1662	0.045 14	0.048 04	0.049 01	0.049 98	0.054 82	0.059 65	0000
000	409.6	167 800.	.1318	.056 93	.060 58	.061 80	.063 03	.069 12	.075 22	000
00	364.8	133 100.	.1045	.071 78	.076 39	.077 93	.079 47	.087 16	.094 85	00
0	324.9	105 500.	.082 89	.090 52	.096 33	.098 27	.1002	.1099	.1196	0
1	289.3	83 690.	.065 73	.1141	.1215	.1239	.1264	.1386	.1508	1
2	257.6	66 370.	.052 13	.1439	.1532	.1563	.1594	.1748	.1902	2
3	229.4	52 640.	.041 34	.1815	.1931	.1970	.2009	.2204	.2398	3
4	204.3	41 740.	.032 78	.2288	.2436	.2485	.2534	.2779	.3024	4
5	181.9	33 100.	.026 00	.2886	.3071	.3133	.3195	.3504	.3813	5
6	162.0	26 250.	.020 62	.3639	.3872	.3951	.4029	.4418	.4808	6
7	144.3	20 820.	.016 35	.4589	.4883	.4982	.5080	.5572	.6064	7
8	128.5	16 510.	.012 97	.5786	.6158	.6282	.6406	.7025	.7645	8
9	114.4	13 090.	.010 28	.7296	.7765	.7921	.8078	.8860	.9641	9
10	101.9	10 380.	.008 155	.9200	.9792	.9989	1.019	1.117	1.216	10
11	90.74	8234.	.006 467	1.160	1.235	1.260	1.284	1.409	1.533	11
12	80.81	6530.	.005 129	1.463	1.557	1.588	1.620	1.776	1.933	12
13	71.96	5178.	.004 067	1.845	1.963	2.003	2.042	2.240	2.438	13
14	64.08	4107.	.003 225	2.326	2.475	2.525	2.576	2.824	3.074	14
15	57.07	3257.	.002 558	2.933	3.121	3.184	3.248	3.562	3.876	15
16	50.82	2583.	.002 028	3.699	3.936	4.015	4.095	4.491	4.887	16
17	45.26	2048.	.001 609	4.664	4.963	5.064	5.164	5.663	6.162	17

18	40.30	1624.	.001 276	5.881	6.259	6.385	6.512	7.141	7.771	18
19	35.89	1288.	.001 012	7.416	7.892	8.051	8.210	9.004	9.799	19
20	31.96	1022.	.000 802 3	9.352	9.953	10.15	10.35	11.36	12.36	20
21	28.46	810.1	.000 636 3	11.79	12.55	12.80	13.06	14.32	15.58	21
22	25 35	642.4	.000 504 6	14.87	15.82	16.14	16.46	18.06	19.65	22
23	22.57	509.5	.000 400 2	18.75	19.95	20.36	20.76	22.77	24.78	23
24	20.10	404.0	.000 317 3	23.64	25.16	25.67	26.18	28.71	31.24	24
25	17.90	320.4	.000 251 7	29.81	31.73	32.37	33.01	36.20	39.39	25
26	15.94	254.1	.000 199 6	37.59	40.01	40.82	41.62	45.65	49.68	26
27	14.20	201.5	.000 158 3	47.40	50.45	51.46	52.48	57.56	62.64	27
28	12.64	159.8	.000 125 5	59.77	63.61	64.90	66.18	72.59	78.98	28
29	11.26	126.7	.000 099 53	75.37	80.22	81.84	83.46	91.53	99.00	29
30	10.03	100.5	.000 078 94	95.05	101.2	103.2	105.2	115.4	125.6	30
31	8.928	79.70	.000 062 60	119.8	127.6	130.1	132.7	145.5	158.4	31
32	7.950	63.21	.000 049 64	151.1	160.8	164.1	167.3	183.5	199.7	32
33	7.080	50.13	.000 039 37	190.6	202.8	206.9	211.0	231.4	251.8	33
34	6.305	39.75	.000 031 22	240.3	255.7	260.9	266.1	291.8	317.5	34
35	5.615	31.52	.000 024 76	303.0	322.5	329.0	335.5	367.9	400.4	35
36	5.000	25.00	.000 019 64	382.1	406.6	414.8	423.0	464.0	504.9	36
37	4.453	19.83	.000 015 57	481.8	512.8	523.1	533.5	585.1	636.7	37
38	3.965	15.72	.000 012 35	607.5	646.6	659.6	672.7	737.7	802.8	38
39	3.531	12.47	.000 009 793	766.1	815.4	831.8	848.2	930.2	1012.0	39
40	3.145	9.888	.000 007 766	966.1	1028.	1049.	1070.	1173.	1276.	40

TABLE I (Part 2) — Continued

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER — Continued

American Wire Gauge (B. & S.). **English Units** — Continued

Gauge No.	Diameter in mils	Pounds per 1000 feet	Feet per pound	Feet per ohm						Gauge No.
				0° C (=32° F)	15° C (=59° F)	20° C (=68° F)	25° C (=77° F)	50° C (=122° F)	75° C (=167° F)	
0000	460.0	640.5	1.561	22 150.	20 810	20 400.	20 010.	18 240.	16 760.	0000
000	409.6	507.9	1.968	17 570.	16 510.	16 180.	15 870.	14 470.	13 290.	000
00	364.8	402.8	2.482	13 930.	13 090.	12 830.	12 580.	11 470.	10 540.	00
0	324.9	319.5	3.130	11 050.	10 380.	10 180.	9979.	9098.	8361.	0
1	289.3	253.3	3.947	8751.	8233.	8070.	7913.	7215.	6630.	1
2	257.6	200.9	4.977	6948.	6529.	6400.	6276.	5722.	5258.	2
3	229.4	159.3	6.276	5510.	5178.	5075.	4977.	4538.	4170.	3
4	204.3	126.4	7.914	4370.	4106.	4025.	3947.	3599.	3307.	4
5	181.9	100.2	9.980	3465.	3256.	3192.	3130.	2854.	2622.	5
6	162.0	79.46	12.58	2748.	2582.	2531.	2482.	2263.	2080.	6
7	144.3	63.02	15.87	2179.	2048.	2007.	1968.	1795.	1649.	7
8	128.5	49.98	20.01	1728.	1624.	1592.	1561.	1423.	1308.	8
9	114.4	39.63	25.23	1371.	1288.	1262.	1238.	1129.	1037.	9
10	101.9	31.43	31.82	1087.	1021.	1001.	981.8	895.1	822.6	10
11	90.74	24.92	40.12	862.0	810.0	794.0	778.5	709.9	652.4	11
12	80.81	19.77	50.59	683.6	642.3	629.6	617.4	563.0	517.3	12
13	71.96	15.68	63.80	542.0	509.4	499.3	489.6	446.4	410.3	13
14	64.08	12.43	80.44	429.9	404.0	396.0	388.3	354.0	325.4	14
15	57.07	9.858	101.4	340.9	320.4	314.0	307.9	280.8	258.0	15
16	50.82	7.818	127.9	270.4	254.1	249.0	244.2	222.7	204.6	16
17	45.26	6.200	161.3	214.4	201.5	197.5	193.7	176.6	162.3	17

18	40.30	4.917	203.4	170.0	159.8	156.6	153.6	140.0	128.7	18
19	35.89	3.899	256.5	134.8	126.7	124.2	121.8	111.1	102.0	19
20	31.96	3.092	323.4	106.9	100.5	98.49	96.59	88.07	80.93	20
21	28.46	2.452	407.8	84.81	79.69	78.11	76.60	69.84	64.18	21
22	25.35	1.945	514.2	67.25	63.20	61.95	60.74	55.39	50.90	22
23	22.57	1.542	648.4	53.34	50.12	49.12	48.17	43.92	40.36	23
24	20.10	1.223	817.7	42.30	39.74	38.96	38.20	34.83	32.01	24
25	17.90	0.9699	1031.	33.54	31.52	30.90	30.30	27.62	25.39	25
26	15.94	.7692	1300.	26.60	25.00	24.50	24.02	21.91	20.13	26
27	14.20	.6100	1639.	21.10	19.82	19.43	19.05	17.37	15.96	27
28	12.64	.4837	2067.	16.73	15.72	15.41	15.11	13.78	12.66	28
29	11.26	.3836	2607.	13.27	12.47	12.22	11.98	10.93	10.04	29
30	10.03	.3042	3287.	10.52	9.886	9.691	9.503	8.665	7.962	30
31	8.928	.2413	4145.	8.344	7.840	7.685	7.536	6.871	6.314	31
32	7.950	.1913	5227.	6.617	6.218	6.094	5.976	5.449	5.008	32
33	7.080	.1517	6591.	5.247	4.931	4.833	4.739	4.322	3.971	33
34	6.305	.1203	8310.	4.161	3.910	3.833	3.759	3.427	3.149	34
35	5.615	.095 42	10 480.	3.300	3.101	3.040	2.981	2.718	2.497	35
36	5.000	.075 68	13 210.	2.617	2.459	2.410	2.364	2.155	1.981	36
37	4.453	.060 01	16 660.	2.075	1.950	1.912	1.874	1.709	1.571	37
38	3.965	.047 59	21 010.	1.646	1.547	1.516	1.487	1.356	1.246	38
39	3.531	.037 74	26 500.	1.305	1.226	1.202	1.179	1.075	0.9878	39
40	3.145	.029 93	33 410.	1.035	0.9727	0.9534	0.9349	0.8525	.7834	40

Table continued on next page Explanatory notes given at end of Table II.

TABLE I (Part 3) — Continued

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER — Continued

American Wire Gauge (B. & S.). **English Units** — Continued

Gauge No.	Diameter in mils	Ohms per pound						Gauge No.
		0° C (=32° F)	15° C (=59° F)	20° C (=68° F)	25° C (=77° F)	50° C (=122° F)	75° C (=167° F)	
0000	460.0	0.000 070 41	0.000 075 09	0.000 076 52	0.000 078 05	0.000 085 70	0.000 093 34	0000
000	409.6	.000 1120	.000 1192	.000 1217	.000 1241	.000 1363	.000 1483	000
00	364.8	.000 1780	.000 1896	.000 1935	.000 1974	.000 2167	.000 2360	00
0	324.9	.000 2830	.000 3015	.000 3076	.000 3138	.000 3445	.000 3753	0
1	289.3	.000 4500	.000 4794	.000 4891	.000 4990	.000 5478	.000 5967	1
2	257.6	.000 7156	.000 7622	.000 7778	.000 7934	.000 8711	.000 9487	2
3	229.4	.001 138	.001 212	.001 237	.001 262	.001 385	.001 508	3
4	204.3	.001 809	.001 927	.001 966	.002 006	.002 202	.002 399	4
5	181.9	.002 877	.003 064	.003 127	.003 189	.003 502	.003 813	5
6	162.0	.004 574	.004 872	.004 972	.005 071	.005 568	.006 065	6
7	144.3	.007 273	.007 747	.007 906	.008 064	.008 853	.009 643	7
8	128.5	.011 56	.012 32	.012 57	.012 82	.014 08	.015 33	8
9	114.4	.018 39	.019 59	.019 99	.020 39	.022 38	.024 38	9
10	101.9	.029 24	.031 15	.031 78	.032 42	.035 59	.038 77	10
11	90.74	.046 49	.049 52	.050 53	.051 55	.056 60	.061 64	11
12	80.81	.073 93	.078 74	.080 35	.081 96	.089 99	.098 01	12
13	71.96	.1176	.1252	.1278	.1303	.1431	.1558	13
14	64.08	.1869	.1991	.2032	.2072	.2275	.2478	14
15	57.07	.2972	.3166	.3230	.3295	.3616	.3940	15
16	50.82	.4726	.5033	.5136	.5239	.5752	.6265	16
17	45.26	.7514	.8003	.8167	.8330	.9146	.9962	17

18	40.30	1.195	1.273	1.299	1.325	1.454	1.584	18
19	35.89	1.900	2.024	2.065	2.106	2.313	2.519	19
20	31.96	3.021	3.218	3.283	3.349	3.677	4.006	20
21	28.46	4.803	5.116	5.221	5.325	5.846	6.368	21
22	25.35	7.637	8.135	8.302	8.467	9.296	10.13	22
23	22.57	12.14	12.93	13.20	13.46	14.78	16.10	23
24	20.10	19.31	20.57	20.99	21.41	23.50	25.60	24
25	17.90	30.70	32.70	33.37	34.04	37.37	40.71	25
26	15.94	48.82	52.00	53.06	54.13	59.43	64.73	26
27	14.20	77.63	82.69	84.37	86.07	94.49	102.9	27
28	12.64	123.4	131.5	134.2	136.8	150.2	163.7	28
29	11.26	196.3	209.1	213.3	217.6	238.9	260.2	29
30	10.03	312.1	332.4	339.2	346.0	379.9	413.8	30
31	8.928	496.3	528.5	539.3	550.2	604.0	657.9	31
32	7.950	789.1	840.5	857.6	874.8	960.4	1046.	32
33	7.080	1255.	1336.	1364.	1391.	1527.	1663.	33
34	6.305	1995.	2125.	2168.	2212.	2428.	2645.	34
35	5.615	3172.	3379.	3448.	3517.	3861.	4205.	35
36	5.000	5044.	5372.	5482.	5597.	6139.	6687.	36
37	4.453	8020.	8542.	8717.	8892.	9762.	10 630.	37
38	3.965	12 750.	13 580.	13 860.	14 140.	15 520.	10 900.	38
39	3.531	20 280.	21 600.	22 040.	22 480.	24 680.	26 880.	39
40	3.145	32 240.	34 340.	35 040.	35 740.	39 250.	42 750.	40

TABLE I (Part 4) — Concluded

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER — Concluded.

American Wire Gauge (B. & S.). **English Units** — Concluded.

Gauge No.	Diameter in mils	Pounds per ohm						Gauge No.
		0° C (=32° F)	15° C (=59° F)	20° C (=68° F)	25° C (=77° F)	50° C (=122° F)	75° C (=167° F)	
0000	460.	14 200.	13 340.	13 070.	12 810.	11 670.	10 710.	0000
000	409.	8933.	8387.	8219.	8057.	7339.	6738.	000
00	364.	5618.	5274.	5169.	5067.	4615.	4237.	00
0	324.9	3533.	3317.	3251.	3187.	2903.	2665.	0
1	289.3	2222.	2086.	2044.	2004.	1826.	1676.	1
2	257.6	1396.	1312.	1286.	1260.	1148.	1054.	2
3	229.4	878.9	825.1	808.6	792.7	722.0	662.9	3
4	204.3	552.7	518.9	508.5	498.6	454.1	416.9	4
5	181.9	347.6	326.4	319.8	313.5	285.6	262.2	5
6	162.0	218.6	205.2	201.1	197.2	179.6	164.9	6
7	144.3	137.5	129.1	126.5	124.0	112.9	103.7	7
8	128.5	86.47	81.18	79.56	77.99	71.04	65.22	8
9	114.4	54.38	51.05	50.03	49.05	44.67	41.02	9
10	101.9	34.20	32.11	31.47	30.85	28.10	25.79	10
11	90.74	21.51	20.19	19.79	19.40	17.67	16.22	11
12	80.81	13.53	12.70	12.44	12.20	11.11	10.20	12
13	71.96	8.507	7.987	7.827	7.673	6.989	6.416	13
14	64.08	5.350	5.023	4.922	4.826	4.395	4.035	14
15	57.07	3.365	3.159	3.096	3.035	2.764	2.538	15
16	50.82	2.126	1.987	1.947	1.909	1.738	1.596	16
17	45.26	1.331	1.250	1.224	1.200	1.093	1.004	17

18	40.30	0.8370	0.7858	0.7701	0.7549	0.6876	0.6313	18
19	35.89	.5264	.4942	.4843	.4748	.4324	.3970	19
20	31.96	.3310	.3108	.3046	.2986	.2719	.2497	20
21	28.46	.2082	.1955	.1915	.1878	.1710	.1570	21
22	25.35	.1309	.1229	.1205	.1181	.1076	.098 76	22
23	22.57	.082 34	.077 31	.075 76	.074 27	.067 65	.062 11	23
24	20.10	.051 79	.048 62	.047 65	.046 71	.042 54	.039 06	24
25	17.90	.032 57	.030 58	.029 97	.029 38	.026 76	.024 56	25
26	15.94	.020 48	.019 23	.018 84	.018 47	.016 83	.015 45	26
27	14.20	.012 88	.012 09	.011 85	.011 62	.010 58	.009 716	27
28	12.64	.008 101	.007 606	.007 454	.007 307	.006 656	.006 110	28
29	11.26	.005 095	.004 783	.004 688	.004 595	.004 186	.003 843	29
30	10.03	.003 204	.003 008	.002 948	.002 890	.002 632	.002 417	30
31	8.928	.002 015	.001 892	.001 854	.001 818	.001 656	.001 520	31
32	7.950	.001 267	.001 190	.001 166	.001 143	.001 041	.000 9559	32
33	7.080	.000 7971	.000 7483	.000 7333	.000 7189	.000 6548	.000 6012	33
34	6.305	.000 5013	.000 4706	.000 4612	.000 4521	.000 4118	.000 3781	34
35	5.615	.000 3152	.000 2960	.000 2900	.000 2843	.000 2590	.000 2378	35
36	5.000	.000 1983	.000 1861	.000 1824	.000 1788	.000 1629	.000 1495	36
37	4.453	.000 1247	.000 1171	.000 1147	.000 1125	.000 1024	.000 094 05	37
38	3.965	.000 078 42	.000 073 63	.000 072 16	.000 070 74	.000 064 43	.000 059 14	38
39	3.531	.000 049 32	.000 046 30	.000 045 38	.000 044 48	.000 040 52	.000 037 20	39
40	3.145	.000 031 02	.000 029 12	.000 028 54	.000 027 98	.000 025 48	.000 023 39	40

Explanatory notes given at end of Table II

TABLE II (Part 1)

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER

American Wire Gauge (B. & S.). **Metric Units**

Gauge No.	Diameter in mm	Cross section in mm²	Ohms per kilometer						Gauge No.
			0° C	15° C	20° C	25° C	50° C	75° C	
0000	11.68	107.2	0.1481	0.1576	0.1608	0.1640	0.1798	0.1957	0000
000	10.40	85.03	.1868	.1988	.2028	.2068	.2268	.2468	000
00	9.266	67.43	.2355	.2506	.2557	.2607	.2860	.3112	00
0	8.252	53.48	.2970	.3161	.3224	.3288	.3606	.3924	0
1	7.348	42.41	.3744	.3985	.4066	.4146	.4547	.4948	1
2	6.544	33.63	.4722	.5025	.5126	.5228	.5733	.6240	2
3	5.827	26.67	.5954	.6336	.6464	.6592	.7230	.7868	3
4	5.189	21.15	.7508	.7990	.8152	.8312	.9117	.9921	4
5	4.621	16.77	.9467	1.008	1.028	1.048	1.150	1.251	5
6	4.115	13.30	1.194	1.270	1.296	1.322	1.450	1.578	6
7	3.665	10.55	1.505	1.602	1.634	1.667	1.828	1.989	7
8	3.264	8.366	1.898	2.020	2.061	2.102	2.305	2.508	8
9	2.906	6.634	2.394	2.547	2.599	2.650	2.906	3.163	9
10	2.588	5.261	3.018	3.212	3.277	3.342	3.665	3.988	10
11	2.305	4.172	3.806	4.050	4.132	4.214	4.622	5.029	11
12	2.053	3.309	4.799	5.108	5.211	5.314	5.828	6.342	12
13	1.828	2.624	6.052	6.441	6.571	6.701	7.349	7.997	13
14	1.628	2.081	7.631	8.122	8.285	8.450	9.267	10.08	14
15	1.450	1.650	9.622	10.24	10.45	10.65	11.68	12.72	15
16	1.291	1.309	12.13	12.91	13.18	13.44	14.73	16.03	16
17	1.150	1.038	15.30	16.28	16.61	16.94	18.58	20.22	17

18	1.024	0.8231	19.29	20.53	20.95	21.35	23.43	25.50	18
19	0.9116	.6527	24.33	25.89	26.42	26.94	29.54	32.15	19
20	.8118	.5176	30.68	32.65	33.31	33.97	37.25	40.54	20
21	.7230	.4105	38.68	41.17	42.00	42.83	46.97	51.12	21
22	.6438	.3255	48.78	51.92	52.96	54.01	59.23	64.46	22
23	.5733	.2582	61.51	65.46	66.79	68.11	74.69	81.29	23
24	.5106	.2047	77.56	82.55	84.22	85.88	94.19	102.5	24
25	.4547	.1624	97.81	104.1	106.2	108.3	118.8	129.2	25
26	.4049	.1288	123.3	131.3	133.9	136.6	149.8	163.0	26
27	.3606	.1021	155.5	165.5	168.8	172.2	188.8	205.5	27
28	.3211	.080 98	196.1	208.6	212.9	217.1	238.1	259.1	28
29	.2859	.064 22	247.3	263.2	268.5	273.8	300.3	326.8	29
30	.2546	.050 93	311.8	331.9	338.6	345.2	378.6	412.0	30
31	.2268	.040 39	393.2	418.5	426.9	435.4	477.5	519.6	31
32	.2019	.032 03	495.8	527.7	538.3	549.0	602.0	655.2	32
33	.1798	.025 40	625.2	665.4	678.8	692.2	759.2	826.2	33
34	.1601	.020 14	788.3	839.0	856.0	872.9	957.3	1042.	34
35	.1426	.015 97	994.2	1058.	1079.	1101.	1207.	1314.	35
36	.1270	.012 67	1254.	1334.	1361.	1388.	1522.	1656.	36
37	.1131	.010 05	1581.	1682.	1716.	1750.	1920.	2089.	37
38	.1007	.007 967	1993.	2120.	2164.	2207.	2420.	2034.	38
39	.089 69	.006 318	2513.	2675.	2729.	2783.	3052.	3321.	39
40	.079 87	.005 010	3170.	3373.	3441.	3509.	3849.	4188.	40

TABLE II (Part 2) — Continued

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER — Continued

American Wire Gauge (B. & S.). **Metric Units** — Continued

Gauge No.	Diameter in mm	Kilograms per kilometer	Meters per gram	Meters per ohm						Gauge No.
				0° C	15° C	20° C	25° C	50° C	75° C	
0000	11.68	953.2	0.001 049	6752.	6344.	6219.	6098.	5560.	5110.	0000
000	10.40	755.9	.001 323	5354.	5031.	4932.	4836.	4410.	4052.	000
00	9.266	599.5	.001 668	4246.	3990.	3911.	3835.	3497.	3213.	00
0	8.252	475.4	.002 103	3367.	3164.	3102.	3042.	2773.	2548.	0
1	7.348	377.0	.002 652	2670.	2509.	2460.	2412.	2198.	2021.	1
2	6.544	299.0	.003 345	2118.	1990.	1951.	1913.	1744.	1603.	2
3	5.827	237.1	.004 217	1679.	1578.	1547.	1517.	1383.	1271.	3
4	5.189	188.0	.005 318	1332.	1252.	1227.	1203.	1097.	1008.	4
5	4.621	149.1	.006 706	1056.	992.5	972.8	954.0	869.8	799.3	5
6	4.115	118.2	.008 457	837.6	787.1	771.5	756.5	689.8	633.9	6
7	3.665	93.78	.010 66	664.3	624.2	611.8	600.0	547.1	502.7	7
8	3.264	74.37	.013 45	526.8	495.0	485.2	475.8	433.8	398.7	8
9	2.906	58.98	.016 96	417.8	392.6	384.8	377.3	344.0	316.2	9
10	2.588	46.77	.021 38	331.3	311.3	305.2	299.2	272.8	250.7	10
11	2.305	37.09	.026 96	262.7	246.9	242.0	237.3	216.4	198.8	11
12	2.053	29.42	.034 00	208.4	195.8	191.9	188.2	171.6	157.7	12
13	1.828	23.33	.042 87	165.2	155.3	152.2	149.2	136.1	125.0	13
14	1.628	18.50	.054 06	131.0	123.1	120.7	118.4	107.9	99.17	14
15	1.450	14.67	.068 16	103.9	97.65	95.72	93.86	85.58	78.65	15
16	1.291	11.63	.085 95	82.41	77.44	75.90	74.43	67.87	62.37	16
17	1.150	9.226	.1084	65.35	61.41	60.19	59.02	53.82	49.46	17

18	1.024	7.317	.1367	51.83	48.70	47.74	46.81	42.68	39.22	18
19	0.9116	5.803	.1723	41.10	38.62	37.86	37.12	33.85	31.10	19
20	.8118	4.602	.2173	32.60	30.63	30.02	29.44	26.84	24.67	20
21	.7230	3.649	.2740	25.85	24.29	23.81	23.35	21.29	19.56	21
22	.6438	2.894	.3455	20.50	19.26	18.88	18.52	16.88	15.51	22
23	.5733	2.295	.4357	16.26	15.28	14.97	14.68	13.39	12.30	23
24	.5106	1.820	.5494	12.89	12.11	11.87	11.64	10.62	9.756	24
25	.4547	1.443	.6928	10.22	9.607	9.417	9.234	8.420	7.737	25
26	.4049	1.145	.8736	8.108	7.619	7.468	7.323	6.677	6.136	26
27	.3606	0.9078	1.102	6.430	6.042	5.922	5.807	5.295	4.866	27
28	.3211	.7199	1.389	5.099	4.791	4.696	4.605	4.199	3.859	28
29	.2859	.5709	1.752	4.044	3.800	3.725	3.652	3.330	3.000	29
30	.2546	.4527	2.209	3.207	3.013	2.954	2.897	2.641	2.427	30
31	.2268	.3590	2.785	2.543	2.390	2.342	2.297	2.094	1.925	31
32	.2019	.2847	3.512	2.017	1.895	1.858	1.822	1.661	1.526	32
33	.1798	.2258	4.429	1.599	1.503	1.473	1.445	1.317	1.210	33
34	.1601	.1791	5.584	1.268	1.192	1.168	1.146	1.045	0.9599	34
35	.1426	.1420	7.042	1.006	0.9451	0.9264	0.9085	0.8284	.7012	35
36	.1270	.1126	8.879	0.7977	.7496	.7347	.7205	.6570	.6037	36
37	.1131	.089 31	11.20	.6326	.5944	.5827	.5714	.5210	.4787	37
38	.1007	.070 83	14.12	.5017	.4714	.4621	.4531	.4132	.3797	38
39	.089 69	.056 17	17.80	.3978	.3738	.3664	.3593	.3276	.3011	39
40	.079 87	.044 54	22.45	.3155	.2965	.2906	.2850	.2598	.2388	40

Table ontinued on next page. Explanatory notes given at end of table.

TABLE II (Part 3) — Continued

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER — Continued

American Wire Gauge (B. & S.). **Metric Units** — Continued

Gauge No.	Diameter in mm	Ohms per kilogram						Gauge No.
		0° C	15° C	20° C	25° C	50° C	75° C	
0000	11.68	0.000 155 2	0.000 165 3	0.000 168 7	0.000 172 1	0.000 188 9	0.000 205 8	0000
000	10.40	.000 246 8	.000 262 9	.000 268 2	.000 273 6	.000 300 4	.000 327 2	000
00	9.266	.000 392 4	.000 418 0	.000 426 5	.000 435 1	.000 477 7	.000 520 3	00
0	8.252	.000 624 0	.000 664 6	.000 678 2	.000 691 8	.000 759 5	.000 827 3	0
1	7.348	.000 992 2	.001 057	.001 078	.001 100	.001 208	.001 316	1
2	6.544	.001 578	.001 680	.001 715	.001 749	.001 920	.002 092	2
3	5.827	.002 508	.002 672	.002 726	.002 781	.003 053	.003 326	3
4	5.189	.003 989	.004 248	.004 335	.004 422	.004 855	.005 288	4
5	4.621	.006 342	.006 755	.006 893	.007 031	.007 720	.008 408	5
6	4.115	.010 08	.010 73	.010 96	.011 18	.012 28	.013 37	6
7	3.665	.016 04	.017 08	.017 43	.017 78	.019 52	.021 26	7
8	3.264	.025 50	.027 16	.027 71	.028 27	.031 04	.033 80	8
9	2.906	.040 54	.043 18	.044 07	.044 95	.049 35	.053 75	9
10	2.588	.064 46	.068 66	.070 06	.071 47	.078 47	.085 47	10
11	2.305	.1025	.1092	.1114	.1136	.1248	.1359	11
12	2.053	.1630	.1736	.1771	.1807	.1984	.2161	12
13	1.828	.2592	.2760	.2817	.2873	.3154	.3436	13
14	1.628	.4121	.4389	.4479	.4569	.5016	.5464	14
15	1.450	.6552	.6979	.7121	.7264	.7975	.8686	15
16	1.291	1.042	1.110	1.132	1.155	1.268	1.381	16
17	1.150	1.656	1.765	1.800	1.837	2.017	2.195	17

18	1.024	2.634	2.806	2.863	2.920	3.206	3.492	18
19	0.9116	4.092	4.461	4.552	4.644	5.098	5.553	19
20	.8118	6.660	7.094	7.238	7.383	8.107	8.830	20
21	.7230	10.59	11.28	11.51	11.74	12.89	14.04	21
22	.6438	16.84	17.93	18.30	18.67	20.49	22.32	22
23	.5733	26.77	28.51	29.10	29.08	32.59	35.50	23
24	.5106	42.57	45.34	46.27	47.20	51.82	56.44	24
25	.4547	67.69	72.10	73.57	75.05	82.39	89.75	25
26	.4049	107.6	114.6	117.0	119.3	131.0	142.7	26
27	.3606	171.1	182.3	186.0	189.8	208.3	226.9	27
28	.3211	272.1	289.8	295.8	301.7	331.2	360.8	28
29	.2859	432.7	460.9	470.3	479.7	526.7	573.7	29
30	.2546	688.0	732.8	747.8	762.7	837.5	912.2	30
31	.2268	1094.	1165.	1189.	1213.	1332.	1450.	31
32	.2019	1740.	1853.	1891.	1928.	2117.	2306.	32
33	.1798	2766.	2946.	3006.	3066.	3367.	3667.	33
34	.1601	4398.	4684.	4780.	4876.	5353.	5831.	34
35	.1426	6993.	7448.	7601.	7753.	8512.	9272.	35
36	.1270	11 120.	11 840.	12 080.	12 330.	13 540.	14 740.	36
37	.1131	17 680.	18 830.	19 220.	19 600.	21 520.	23 440.	37
38	.1007	28 110.	29 940.	30 560.	31 170.	34 220.	37 270.	38
39	.089 69	44 700.	47 610.	48 590.	49 560.	54 410.	59 270.	39
40	.079 87	71 080.	75 710.	77 260.	78 800.	86 520.	94 240.	40

TABLE II (Part 4) — Concluded

COMPLETE WIRE TABLE, STANDARD ANNEALED COPPER — Concluded

American Wire Gauge (B. & S.). **Metric Units** — Concluded

Gauge No.	Diameter in mm	Grams per ohm						Gauge No.
		0° C	15° C	20° C	25° C	50° C	75° C	
0000	11.68	6 443 000.	6 049 000.	5 928 000.	5 811 000.	5 293 000.	4 859 000.	0000
000	10.40	4 052 000.	3 803 000.	3 728 000.	3 655 000.	3 329 000.	3 056 000.	000
00	9.266	2 548 000.	2 392 000.	2 344 000.	2 298 000.	2 093 000.	1 922 000.	00
0	8.252	1 603 000.	1 505 000.	1 474 000.	1 446 000.	1 317 000.	1 209 000.	0
1	7.348	1 008 000.	946 200.	927 300.	909 100.	828 000.	760 200.	1
2	6.544	633 900.	595 100.	583 200.	571 700.	520 700.	478 100.	2
3	5.827	398 700.	374 300.	366 800.	359 600.	327 500.	300 700.	3
4	5.189	250 700.	235 400.	230 700.	226 100.	206 000.	189 100.	4
5	4.621	157 700.	148 000.	145 100.	142 200.	129 500.	118 900.	5
6	4.115	99 170.	93 100.	91 230.	89 440.	81 460.	74 790.	6
7	3.665	62 370.	58 550.	57 380.	56 250.	51 230.	47 040.	7
8	3.264	39 220.	36 820.	36 090.	35 380.	32 220.	29 580.	8
9	2.906	24 670.	23 160.	22 690.	22 250.	20 260.	18 600.	9
10	2.588	15 510.	14 560.	14 270.	13 990.	12 740.	11 700.	10
11	2.305	9756.	9160.	8976.	8800.	8015.	7359.	11
12	2.053	6136.	5760.	5645.	5534.	5040.	4628.	12
13	1.828	3859.	3623.	3550.	3480.	3170.	2910.	13
14	1.628	2427.	2278.	2233.	2189.	1994.	1830.	14
15	1.450	1526.	1433.	1404.	1377.	1254.	1151.	15
16	1.291	959.9	901.2	883.1	865.8	788.5	723.9	16
17	1.150	603.7	566.7	555.3	544.4	495.9	455.2	17

18	1.024	379.7	356.4	349.3	342.4	311.9	286.3	18
19	0.9116	238.8	224.2	219.7	215.4	196.2	180.1	19
20	.8118	150.2	141.0	138.2	135.4	123.4	113.2	20
21	.7230	94.44	88.66	86.89	85.18	77.58	71.23	21
22	.6438	59.40	55.76	54.64	53.57	48.79	44.79	22
23	.5733	37.35	35.07	34.36	33.69	30.68	28.17	23
24	.5106	23.49	22.05	21.61	21.19	19.30	17.72	24
25	.4547	14.77	13.87	13.59	13.32	12.14	11.14	25
26	.4049	9.291	8.723	8.548	8.380	7.633	7.007	26
27	.3606	5.343	5.486	5.376	5.270	4.800	4.407	27
28	.3211	3.675	3.450	3.381	3.314	3.019	2.772	28
29	.2859	2.311	2.170	2.126	2.084	1.899	1.743	29
30	.2546	1.454	1.365	1.337	1.311	1.194	1.096	30
31	.2268	0.9140	0.8582	0.8410	0.8244	0.7509	0.6894	31
32	.2019	.5749	.5397	.5289	.5185	.4723	.4336	32
33	.1798	.3616	.3394	.3326	.3261	.2970	.2727	33
34	.1601	.2274	.2135	.2092	.2051	.1868	.1715	34
35	.1426	.1430	.1343	.1316	.1290	.1175	.1079	35
36	.1270	.089 94	.084 44	.082 75	.081 12	.073 89	.067 83	36
37	.1131	.056 56	.053 10	.052 04	.051 01	.046 46	.042 66	37
38	.1007	.035 57	.033 40	.032 73	.032 08	.029 22	.026 83	38
39	.089 69	.022 37	.021 00	.020 58	.020 18	.018 38	.016 87	39
40	.079 87	.014 07	.013 21	.012 94	.012 69	.011 56	.010 61	40

NOTE 1.— The *fundamental resistivity* used in calculating the tables is the Annealed Copper Standard, viz, 0.153 28 ohm (meter, gram) at 20° C. The *temperature coefficient* for this particular resistivity, is α_{20}=0.00393, or α_0 subscripts =0.00427. However, the temperature coefficient is proportional to the conductivity, and hence the change of *resistivity* per degree C is a constant, 0.000 597 ohm (meter, gram). The "constant mass" temperature coefficient of any sample is

$$a_t = \frac{0.000\ 597 + 0.000\ 005}{\text{resistivity in ohms (meter, gram) at } t^\circ \text{ C}}$$

The *density* is 8.89 grams per cubic centimeter.

NOTE 2.— The values given in the tables are only for annealed copper of the standard resistivity. The user of the table must apply the proper correction for copper of any other resistivity. Hard-drawn copper may be taken as about 2.7 per cent higher resistivity than annealed copper.

NOTE 3.— This table is intended as an ultimate reference table, and is computed to a greater precision than is desired in practice. The practical user of a wire table is referred to the "Working Table," No. III.

NOTE 4.— Tables I and II are the same as Tables VI and VII, pages 38–45 inclusive, Circular 31 of the Bureau of Standards.

TABLE III

WORKING TABLE, STANDARD ANNEALED COPPER WIRE

American Wire Gauge (B. & S.)

Gauge No.	Diameter in mils	Cross section in circular mils	Weight in pounds		Resistance at 20° C. (= 68° F.)	
			Per 1,000 feet	Per mile	Ohms per 1,000 feet	Ohms per mile
0000	460.	212 000.	641.	3382.	0.0490	0.259
000	410.	168 000.	508.	2682.	.0618	.326
00	365.	133 000.	403.	2127.	.0779	.411
0	325.	106 000.	319.	1687.	.0983	.519
1	289.	83 700.	253.	1337.	.124	.654
2	258.	66 400.	201.	1061.	.156	.825
3	229.	52 600.	159.	841.	.197	1.04
4	204.	41 700.	126.	667.	.248	1.31
5	182.	33 100.	100.	529.	.313	1.65
6	162.	26 300.	79.5	420.	.395	2.09
7	144.	20 800.	63.0	333.	.498	2.63
8	128.	16 500.	50.0	264.	.628	3.32
9	114.	13 100.	39.6	209.	.792	4.18
10	102.	10 400.	31.4	166.	.999	5.28
11	91.	8230.	24.9	132.	1.26	6.65
12	81.	6530.	19.8	104.	1.59	8.38
13	72.	5180.	15.7	82.8	2.00	10.6
14	64.	4110.	12.4	65.6	2.53	13.3
15	57.	3260.	9.86	52.0	3.18	16.8
16	51.	2580.	7.82	41.3	4.01	21.2
17	45.	2050.	6.20	32.7	5.06	26.8
18	40.	1620.	4.92	26.0	6.39	33.7
19	36.	1290.	3.90	20.6	8.05	42.5
20	32.	1020.	3.09	16.3	10.1	53.6
21	28.5	810.	2.45	12.9	12.8	67.6
22	25.3	642.	1.94	10.3	16.1	85.2
23	22.6	509.	1.54	8.14	20.4	107.
24	20.1	404.	1.22	6.46	25.7	136.
25	17.9	320.	.970	5.12	32.4	171.
26	15.9	254.	.769	4.06	40.8	216.
27	14.2	202.	.610	3.22	51.5	272.
28	12.6	160.	.484	2.55	64.9	343.
29	11.3	127.	.384	2.03	81.8	432.
30	10.0	101.	.304	1.61	103.	545.
31	8.9	79.7	.241	1.27	130.	687.
32	8.0	63.2	.191	1.01	164.	866.
33	7.1	50.1	.152	0.801	207.	1092.
34	6.3	39.8	.120	.635	261.	1378.
35	5.6	31.5	.0954	.504	329.	1737.

TABLE III—(*Concluded*)

Gauge No.	Diameter in mils	Cross section in circular mils	Weight in pounds		Resistance at 20° C. (= 68° F.)	
			Per 1,000 feet	Per mile	Ohms per 1,000 feet	Ohms per mile
36	5.0	25.0	.0757	.400	415.	2190.
37	4.5	19.8	.0600	.317	523.	2762.
38	4.0	15.7	.0476	.251	660.	3483.
39	3.5	12.5	.0377	.199	832.	4392.
40	3.1	9.9	.0299	.158	1050.	5539.

NOTE 1.— The fundamental resistivity used in calculating the table is the Annealed Copper Standard, viz., 0.153 28 ohm (meter, gram) at 20° C. The temperature coefficient for this particular resistivity is $a_{20} = 0.003\ 93$, or $a_0 = 0.004\ 27$. owever, the temperature coefficient is proportional to the conductivity, and hence the change of resistivity per degree C is a constant, 0.000 597 ohm (meter, gram). The " constant mass " temperature coefficient of any sample is

$$a = \frac{0.000\ 597 + 0.000\ 005}{\text{resistivity in ohms (meter, gram) at t° C}}$$

The density is 8.89 grams per cubic centimeter.

NOTE 2.— The values given in the table are only for annealed copper of the standard resistivity. The user of the table must apply the proper correction for copper of any other resistivity. Hard-drawn copper may be taken as about 2.7 per cent. higher resistivity than annealed copper.

NOTE 3.— This table is the same as Table VIII, page 46, circular 31 of the Bureau of Standards, except that Cross Section in square inches is omitted. Resistances are shown at 20 deg. C. instead of 25 deg. C and 65 deg. C., and that Resistances and Weights per mile have been added.

TABLE IV

BARE CONCENTRIC CABLES OF STANDARD ANNEALED COPPER

American wire gauge (B. & S.) number	Circular mils	Weight in pounds		Resistance at 20° C. (= 68° F.)		Standard strands			Flexible strands			Gauge No.
		Per 1000 feet	Per mile	Ohms per 1000 feet	Ohms per mile	Number of wires	Diameter of wires in mils	Outside diameter in mils	Number of wires	Diameter of wires in mils	Outside diameter in mils	
	2 000 000	6180.	32 630	0.005 29	0.0279	127	125.5	1631	169	108.8	1632	
	1 900 000	5870.	30 990	.005 57	.0294	127	122.3	1590	169	106.0	1590	
	1 800 000	5560.	29 360	.005 87	.0310	127	119.1	1548	169	103.2	1548	
	1 700 000	5250.	27 720	.006 23	.0329	127	115.7	1504	169	100.3	1504	
	1 600 000	4940.	26 080	.006 61	.0349	127	112.2	1459	169	97.3	1460	
	1 500 000	4630.	24 450	.007 05	.0372	91	128.4	1412	127	108.7	1413	
	1 400 000	4320.	22 810	.007 56	.0399	91	124.0	1364	127	105.0	1365	
	1 300 000	4010.	21 170	.008 14	.0430	91	119.5	1315	127	101.2	1315	
	1 200 000	3710.	19 590	.008 82	.0466	91	114.8	1263	127	97.2	1264	
	1 100 000	3400.	17 950	.009 62	.0508	91	109.9	1209	127	93.1	1210	
	1 000 000	3090.	16 320	.0106	.0560	61	128.0	1152	91	104.8	1153	
	950 000	2930.	15 470	.0112	.0590	61	124.8	1123	91	102.2	1124	
	900 000	2780.	14 680	.0118	.0623	61	121.5	1093	91	99.4	1094	
	850 000	2620.	13 830	.0125	.0655	61	118.0	1062	91	96.6	1063	
	800 000	2470.	13 040	.0132	.0697	61	114.5	1031	91	93.8	1031	
	750 000	2320.	12 250	.0141	.0746	61	110.9	998	91	90.8	999	
	700 000	2160.	11 400	.0151	.0797	61	107.1	964	91	87.7	965	
	650 000	2010.	10 610	.0163	.0860	61	103.2	929	91	84.5	930	
	600 000	1850.	9770	.0177	.0929	61	99.2	893	91	81.2	893	
	550 000	1700.	8980	.0192	.101	61	95.0	855	91	77.7	855	

	500 000	1540.	8130	.0212	.112	37	116.2	814	61	90.5	815	
	450 000	1390.	7340	.0235	.124	37	110.3	772	61	85.9	773	
	400 000	1240.	6550	.0265	.140	37	104.0	728	61	81.0	729	
	350 000	1080.	5700	.0302	.160	37	97.3	681	61	75.7	682	
	300 000	926.	4890	.0353	.186	37	90.0	630	61	70.1	631	
	250 000	772.	4080	.0424	.224	37	82.2	575	61	64.0	576	
0000	212 000	653.	3450	.0500	.264	19	105.5	528	37	75.6	533	0000
000	168 000	518.	2740	.0631	.333	19	94.0	470	37	67.3	471	000
00	133 000	411.	2170	.0795	.420	19	83.7	418	37	60.0	420	00
0	106 000	326.	1720	.100	.528	19	74.5	373	37	53.4	374	0
1	83 700	258.	1360	.127	.665	19	66.4	332	37	47.6	333	1
2	66 400	205.	1080	.160	.845	7	97.4	292	19	59.1	296	2
3	52 600	163.	861	.201	1.06	7	86.7	260	19	52.6	263	3
4	41 700	129.	681	.253	1.34	7	77.2	232	19	46.9	234	4
5	33 100	102.	539	.320	1.69	7	68.8	206	19	41.7	209	5
6	26 300	81.0	428	.403	2.13	7	61.2	184	19	37.2	186	6
7	20 800	64.3	340	.508	2.68	7	54.5	164	19	33.1	166	7
8	16 500	51.0	269	.640	3.38	7	48.6	146	19	29.5	147	8

NOTE 1.— The fundamental resistivity used in calculating the table is the Annealed Copper standard, viz., 0.153 28 ohm (meter, gram) at 20 deg. C. The temperature coefficient is $\alpha_{20} = 0.003\ 93$, or $\alpha_0 = 0.004\ 27$. The density is 8.89 grams per cubic centimeter.

NOTE 2.— This table is in accord with the standards adopted by the Standards Committee of the American Institute of Electrical Engineers in January, 1912; both in respect to the "number of wires" in "Standard Strands" and "Flexible Strands", and in respect to the correction for increase of resistance and mass due to the twist of the wires. The values given for "Ohms per 1000 feet" and "Pounds per 1000 feet" are 2 per cent greater than for a solid rod of cross section equal to the total cross section of the wires of the cable. This increment of 2 per cent means that the values are correct for cables having a lay of 1 in 15.7. For any other lay, equal to 1 in n, resistance or mass may be calculated by increasing the above tabulated values by $(\frac{484}{n^2} - 2)\%$

NOTE 3.— This table is the same as Table XII, page 50, Circular 31 of the Bureau of Standards, except that Resistances are shown at 20 deg. C. instead of 25 deg. C. and 65 deg. C., and that Resistances and Weights per mile have been added.

TABLE V

HARD-DRAWN ALUMINUM WIRE AT 20° C. (OR, 68° F.)

American Wire Gauge (B. & S.). **English Units**

Gauge No.	Diameter in mils	Cross section		Ohms per 1000 feet	Pounds per 1000 feet	Pounds per ohm	Feet per ohm
		Circular mils	Square inches				
0000	460.	212 000.	0.166	0.0804	195.	2420.	12 400.
000	410.	168 000.	.132	.101	154.	1520.	9860.
00	365.	133 000.	.105	.128	122.	957.	7820.
0	325.	106 000.	.0829	.161	97.0	602.	6200.
1	289.	83 700.	.0657	.203	76.9	379.	4920.
2	258.	66 400.	.0521	.256	61.0	238.	3900.
3	229.	52 600.	.0413	.323	48.4	150.	3090.
4	204.	41 700.	.0328	.408	38.4	94.2	2450.
5	182.	33 100.	.0260	.514	30.4	59.2	1950.
6	162.	26 300.	.0206	.648	24.1	37.2	1540.
7	144.	20 800.	.0164	.817	19.1	23.4	1220.
8	128.	16 500.	.0130	1.03	15.2	14.7	970.
9	114.	13 100.	.0103	1.30	12.0	9.26	770.
10	102.	10 400.	.008 15	1.64	9.55	5.83	610.
11	91.	8230.	.006 47	2.07	7.57	3.66	484.
12	81.	6530.	.005 13	2.61	6.00	2.30	384.
13	72.	5180.	.004 07	3.29	4.76	1.45	304.
14	64.	4110.	.003 23	4.14	3.78	0.911	241.
15	57.	3260.	.002 56	5.22	2.99	.573	191.
16	51.	2580.	.002 03	6.59	2.37	.360	152.
17	45.	2050.	.001 61	8.31	1.88	.227	120.
18	40.	1620.	.001 28	10.5	1.49	.143	95.5
19	36.	1290.	.001 01	13.2	1.18	.0897	75.7
20	32.	1020.	.000 802	16.7	0.939	.0564	60.0
21	28.5	810.	.000 636	21.0	.745	.0355	47.6
22	25.3	642.	.000 505	26.5	.591	.0223	37.8
23	22.6	509.	.000 400	33.4	.468	.0140	29.9
24	20.1	404.	.000 317	42.1	.371	.008 82	23.7
25	17.9	320.	.000 252	53.1	.295	.005 55	18.8
26	15.9	254.	.000 200	67.0	.234	.003 49	14.9
27	14.2	202.	.000 158	84.4	.185	.002 19	11.8
28	12.6	160.	.000 126	106.	.147	.001 38	9.39
29	11.3	127.	.000 099 5	134.	.117	.000 868	7.45
30	10.0	101.	.000 078 9	169.	.0924	.000 546	5.91
31	8.9	79.7	.000 062 6	213.	.0733	.000 343	4.68
32	8.0	63.2	.000 049 6	269.	.0581	.000 216	3.72
33	7.1	50.1	.000 039 4	339.	.0461	.000 136	2.95
34	6.3	39.8	.000 031 2	428.	.0365	.000 085 4	2.34
35	5.6	31.5	.000 024 8	540.	.0290	.000 053 7	1.85
36	5.0	25.0	.000 019 6	681.	.0230	.000 033 8	1.47
37	4.5	19.8	.000 015 6	858.	.0182	.000 021 2	1.17
38	4.0	15.7	.000 012 3	1080.	.0145	.000 013 4	0.924
39	3.5	12.5	.000 009 79	1360.	.0115	.000 008 40	.733
40	3.1	9.9	.000 007 77	1720.	.0091	.000 005 28	.581

NOTE.— This table is the same as Table XIV, page 52, circular 31 of the Bureau of Standards.

APPENDIX D

SPECIFICATIONS FOR GALVANIZING ON IRON AND STEEL

GENERAL DESCRIPTION:

1. These specifications shall apply to all galvanized iron or steel except that coated with zinc by the Sheradizing Process.

COATING:

2. The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness, and so applied that it adheres firmly to the metal. The finished product shall be smooth.

CLEANING:

3. The samples shall be cleaned before testing, first with carbona, benzine or turpentine, and cotton waste (not with a brush), and then thoroughly rinsed in clean water and wiped dry with clean cotton waste.

SOLUTION:

4. The standard solution of copper sulphate shall consist of commercial copper sulphate crystals dissolved in cold water, about in the proportion of thirty-six parts, by weight, of crystals to 100 parts by weight, of water. The solution shall be neutralized by the addition of an excess of chemically pure cupric oxide (CuO). The presence of an excess of cupric oxide will be shown by the sediment of this reagent at the bottom of the containing vessel.

The neutralized solution shall be filtered before using by passing through filter paper. The filtered solution shall have a specific gravity of 1.186 at 65 deg. Fahr. (reading the scale at the level of the solution) at the beginning of each test. In case the filtered solution is high in specific gravity, clean water shall be added to reduce the specific gravity to 1.186 at 65 deg. Fahr. In case the filtered solution is low in specific gravity, filtered solution of a higher specific gravity shall be added to make the specific gravity 1.186 at 65 deg. Fahr.

As soon as the stronger solution is taken from the vessel containing the unfiltered neutralized stock solution, additional crystals and water must be added to the stock solution. An excess of cupric oxide shall always be kept in the unfiltered stock solution.

QUANTITY OF SOLUTION:

5. Wire samples shall be tested in a glass jar of at least two inches (2 in.) inside diameter. The jar without the wire samples shall be filled with standard solution to a depth of at least four inches (4 in.). Hardware samples shall be tested in a glass or earthenware jar containing at least one-half (½) pint of standard solution for each hardware sample.

Solution shall not be used for more than one series of four immersions.

SAMPLES:

6. Not more than seven wires shall be simultaneously immersed, and not more than one sample of galvanized material other than wire shall be immersed in the specified quantity of solution.

The samples shall not be grouped or twisted together, but shall be well separated so as to permit the action of the solution to be uniform upon all immersed portions of the samples.

TESTS:

7. Clean and dry samples shall be immersed in the required quantity of standard solution in accordance with the following cycle of immersions.

The temperature of the solution shall be maintained between 62 and 68 deg. Fahr. at all times during the following test.

First.	Immerse for one minute, wash and wipe dry.
Second.	Immerse for one minute, wash and wipe dry.
Third.	Immerse for one minute, wash and wipe dry.
Fourth.	Immerse for one minute, wash and wipe dry.

After each immersion the samples shall be immediately washed in clean water having a temperature between 62 and 68 deg. Fahr., and wiped dry with cotton waste.

In the case of No. 14 galvanized iron or steel wire, the time of the fourth immersion shall be reduced to one-half minute.

RESULTS OF TESTS:

8. After the tests described in Paragraph 7, no bright metallic copper deposit shall show upon the samples.

In case the article is threaded, the thread shall be clean and true after galvanizing and shall stand at least one immersion in the test solution. The rest of the article shall stand the specified four immersions.

The threads of nuts shall be cut after galvanizing, and the threads shall not be required to pass the tests.

Copper deposits on zinc, or within one inch of a cut end, shall not be considered causes for rejection.

In case of failure of only one wire in a group of seven wires immersed together, or if there is a reasonable doubt as to the copper deposit, two check tests shall be made on these seven wires and the lot reported in accordance with the majority of the sets of tests.

FAILURE TO MEET REQUIREMENTS:

9. Any shipment or part of a shipment, the samples from which fail to pass the above requirements, may be rejected and returned.

Exhibit I

The equipment necessary for the tests herein outlined is as follows:

Filter paper.
Commercial Copper Sulphate crystals.
Chemically pure cupric oxide (CuO).
Running water.
Warm water or ice as per needs.
Carbona, benzine or turpentine.
Glass jars at least two inches inside diameter by at least four and one-half inches high.
Glass or earthenware jars for hardware samples.
Vessel for washing samples.
Tray for holding jars of stock solution.
Jars, bottles and porcelain basket for stock solution.
Cotton waste.
Hydrometer cylinder three inches diameter by fifteen inches high.
Thermometer with large Fahrenheit scale correct at 62 and 68 deg.
Hydrometer correct at 1.186 and 65 deg. Fahr.

APPENDIX E

SUB-DIVISION A

SPECIFICATIONS FOR TILE DUCT FOR ELECTRICAL CONDUIT

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The material desired under these specifications is vitrified clay duct for use in constructing conduits for electric cable.

DIMENSIONS:

3. Each piece of duct must conform in shape and dimensions to the Company's drawing for the kind of duct ordered, but the outside dimension must be uniform. In each shipment there shall be included 2 pieces each of 4 in., 6 in., 8 in., 9 in. and 12 in. lengths, for every thousand feet of duct.

CONSTRUCTION:

4. Each piece of duct must consist of whole, sound, thoroughly vitrified and glazed tile, straight from end to end, with smooth interior surface, free from blisters, sharp corners and obstructions.

The bore must be not less than the nominal diameter ordered, and must be symmetrical with, and the ends must be cut off square with, the longitudinal axis of the duct. The wall of the duct must be not less than 9/16 in. thick at the thinnest place, but the duct must average ⅝ in. thick. The inner edges of the ends of each piece of duct must be chamfered off so that sharp edges will not be encountered when cable is drawn in. The completed duct must have the necessary mechanical strength and toughness to prevent chipping at the ends and breakage in ordinary handling. The outer surface of all duct must be scored approximately as shown on the Company's standard drawing and in such manner as to give cement a hold on the surface of the duct. The inner surface of each piece must be thoroughly scraped before shipment.

INSPECTION:

5. All duct will be subject to inspection at the factory or on delivery, or both, as desired by the Company. The inspection will cover quality and breakage.

REJECTION:

6. Any duct which fails to meet requirements hereinbefore specified may be rejected.

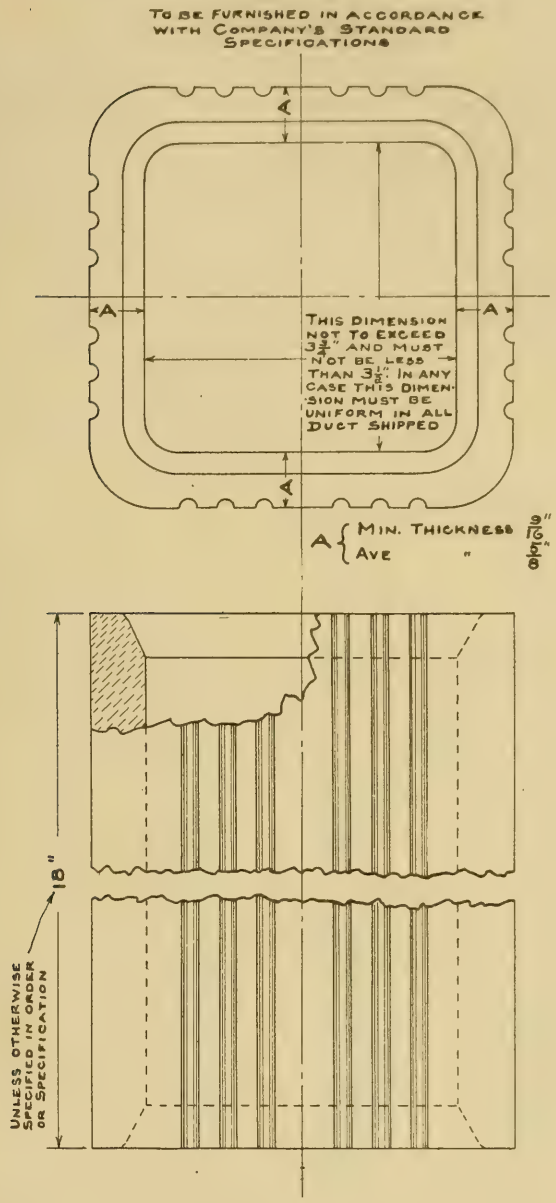

TO BE FURNISHED IN ACCORDANCE WITH COMPANY'S STANDARD SPECIFICATIONS
A
A
A
THIS DIMENSION NOT TO EXCEED 3 3/4" AND MUST NOT BE LESS THAN 3 1/8" IN ANY CASE THIS DIMENSION MUST BE UNIFORM IN ALL DUCT SHIPPED
A { MIN. THICKNESS 9/16"
AVE "
18"
UNLESS OTHERWISE SPECIFIED IN ORDER OR SPECIFICATION

FIG. 2.—SHOWING 3½ IN. SQUARE TILE DUCT.

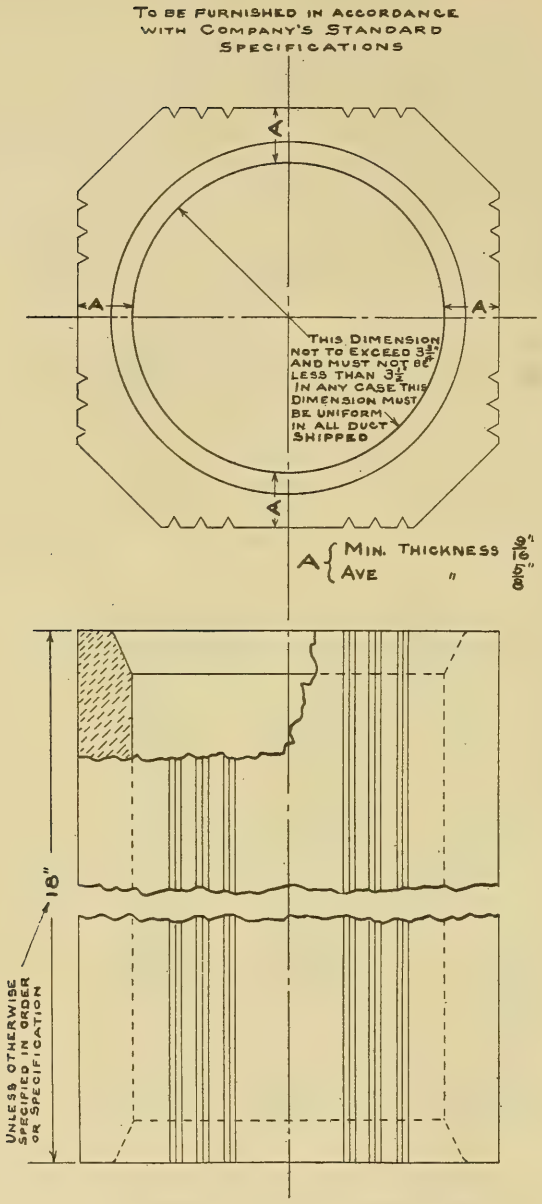

TO BE FURNISHED IN ACCORDANCE WITH COMPANY'S STANDARD SPECIFICATIONS
A
A
A
A
THIS DIMENSION NOT TO EXCEED 3¾" AND MUST NOT BE LESS THAN 3½" IN ANY CASE THIS DIMENSION MUST BE UNIFORM IN ALL DUCT SHIPPED
A { MIN. THICKNESS 5/16"
AVE " 5/8"
18"
UNLESS OTHERWISE SPECIFIED IN ORDER OR SPECIFICATION

FIG. 3.—SHOWING 3½ IN. ROUND DUCT.

SUB-DIVISION B

SPECIFICATIONS FOR POLE STEPS

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GALVANIZED TO THE COMPANY'S STANDARD SPECIFICATIONS

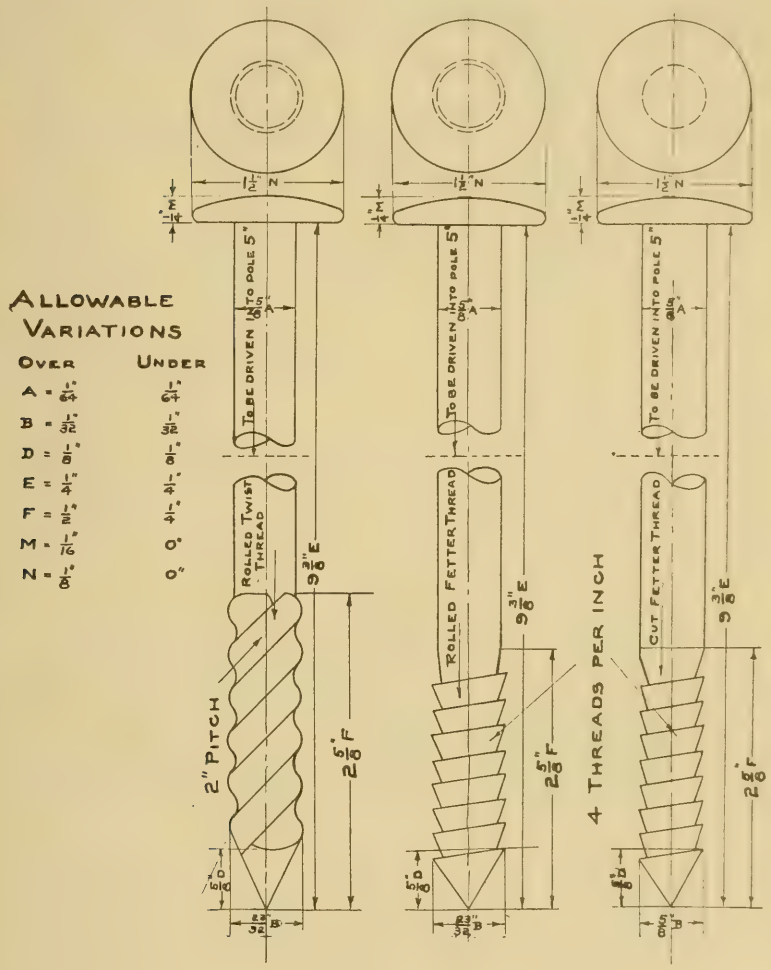


FIG. 4.—SHOWING POLE STEPS.

GENERAL DESCRIPTION:

2. The material required under these specifications are pole steps made of refined wrought iron or mild steel, galvanized. All workmanship on the pole steps must be of the best commercial grade. Where alternatives either of material or form are specified herein, or on the drawing hereinafter referred to, the cheaper form of material must be furnished.

DIMENSIONS:

3. The pole steps must be of the form and dimensions shown on the drawing of the Companies. Where maximum and minimum dimensions are shown, the dimensions must be within the limits specified. Where limits are not shown, the dimensions must be approximate.

MECHANICAL REQUIREMENTS:

4. When held rigidly at the head, the pole steps must be capable of being bent without breaking to an angle of 90 deg. about a diameter equal to the diameter of the pole step.

GALVANIZING:

5. The pole steps must be galvanized in accordance with the Company's standard specification for Galvanizing on Iron and Steel.

INSPECTION:

6. On receipt of a shipment, the pole steps will be inspected and samples taken at random which must pass the above requirements.

FAILURE TO MEET REQUIREMENTS:

7. Any shipment or part of a shipment, the samples of which fail to meet the requirements hereinbefore specified, may be rejected and returned at the expense of the Contractor.

SUB-DIVISION C

SPECIFICATIONS FOR COPPER ARMOR FOR TROLLEY WIRE

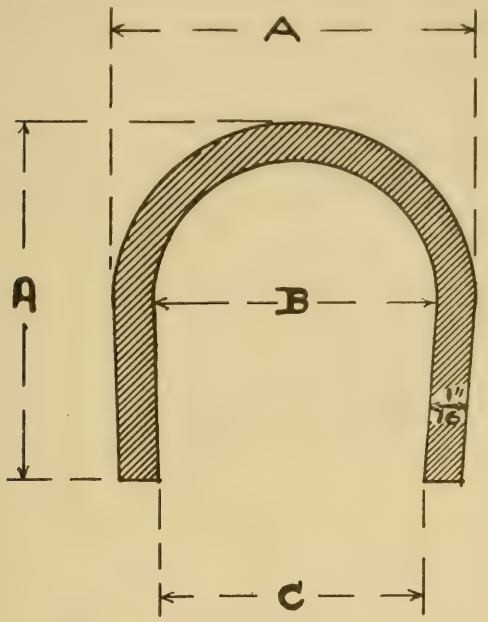
DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The material desired under these specifications is hard-drawn copper trolley armor for 00 or 0000 wire as specified in the order. The completed armor and the material from which it is made shall conform to the following specifications and tests.



TO BE FURNISHED IN 4' LENGTHS

SIZE OF WIRE	A	B	C	D
#2/0	$\frac{1}{2}$"	$\frac{3}{8}$"	$\frac{11}{32}$"	$\frac{1}{2}$"
#4/0	.605"	.480"	$\frac{7}{16}$"	$\frac{19}{32}$"

FIG. 5.— SHOWING COPPER ARMOR FOR TROLLEY WIRE.

DIMENSIONS:

3. All trolley armor furnished under these specifications shall correspond with respect to form and construction to the standard drawing of the Company. A variation of one (1) per cent in either direction will be allowed from the specified dimensions.

COMPOSITION:

4. All armor supplied under these specifications shall be made from pure copper.

MECHANICAL TESTS:

5(*a.*) *Tensile Strength.* All trolley armor supplied under these specifications shall show a tensile strength of not less than forty-six thousand pounds (46,000 lb.) per square inch. This test shall be made on a sample of the finished armor ten inches (10 in.) in length between the grips of the testing machine.

5(*b.*) *Spring.* When subjected to a compression test in the manner hereinafter specified, the armor shall show a permanent deformation of not less than three thousandths (0.003) and not more than five thousandths (0.005) of an inch under a load of two hundred and fifty pounds (250 lb.).

This test shall be carried out in the following manner:

A sample of the armor shall be compressed between two (2) parallel one (1) inch square steel faces with the end of the specimen even with one edge of the steel blocks in such a manner as to tend to bring the two (2) legs of the "U" together. A load of two hundred and fifty (250) pounds shall be applied for one (1) minute, removed and the permanent set at once measured. The deformation shall be measured at a point in the specimen which corresponds to the center of the blocks.

INSPECTION:

6. When a shipment is received samples will be taken at random and submit to the requirements hereabove specified.

FAILURE TO MEET REQUIREMENTS:

7. Any shipment or part of a shipment, which fails to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

SUB-DIVISION D

SPECIFICATIONS FOR COMPOSITION ARMOR FOR TROLLEY WIRE

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

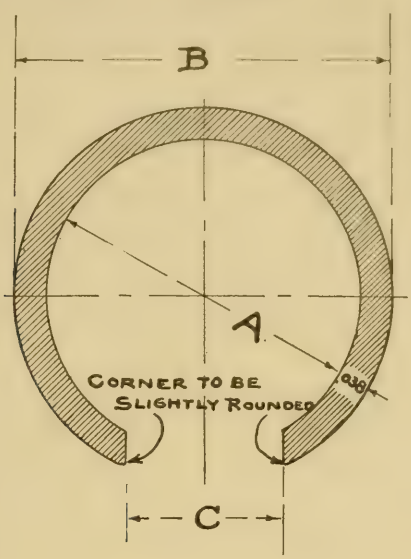
The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The material desired under this specification is composition trolley armor for 0, 00 and 0000 wire as specified in the order. The completed armor and the material from which it is made shall conform to the following specifications and tests.

DIMENSIONS:

3. All trolley armor furnished under these specifications shall correspond with respect to form and construction to the standard drawing of the Company. A variation of 1 per cent in either direction will be allowed from the specified dimensions.



TO BE FURNISHED IN 4' LENGTHS

SIZE	A	B	C
0	.340"	.416"	$\frac{1}{4}$"
00	.380"	.456"	$\frac{9}{32}$"
0000	.475"	.551"	$\frac{11}{32}$"

FIG. 6.— SHOWING COMPOSITION ARMOUR FOR TROLLEY WIRE.

COMPOSITION:

4. All armor supplied under these specifications must show the following composition upon analysis:

Copper	59–62 per cent
Zinc	38–41 per cent.
Metals other than copper and zinc, not over	0.5 per cent.

INSPECTION:

5. When a shipment is received samples will be taken at random and subjected to the requirements hereinabove specified.

FAILURE TO MEET REQUIREMENTS:

6. Any shipment or part of a shipment which fails to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

SUB-DIVISION E

SPECIFICATIONS FOR SOLDER

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The solder desired under these specifications is a homogeneous alloy of lead and tin, uniform in composition, containing not more than a trace of copper, iron or zinc and as free from every other substance as possible.

The quality of the materials used and the methods of manufacture shall be such as to insure for the completed solder the properties called for in these specifications.

REQUIREMENTS:

3. The composition of the various solders supplied under these specifications shall be as follows:

Quality of Solder	Minimum per cent. of tin	Per cent of lead (about)	Maximum per cent of metallic impuritie other than copper an zin
Half and half	50	50	0.5
Fine solder (bar solder)	45	55	0.5
Wire solder	45	55	0.5
Wiping solder	40	60	0·5

INSPECTION:

4. Each shipment shall be inspected and weighed. Drillings taken from any portion of each lot of solder shall be analyzed and the results of the analysis shall be considered to represent the composition of the lot.

METHOD OF SHIPMENT:

5. The completed solder shall be furnished in such form and weight and with such marks as may be specified.

FAILURE TO MEET REQUIREMENTS:

6. Any shipment or part of a shipment which fails to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

SUB-DIVISION F
SPECIFICATIONS FOR CROSS ARM BRACES

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or his duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or his duly authorized representative.

GENERAL DESCRIPTION:

2. The materials required under this specification are cross-arm braces made from iron or steel, galvanized, either flats or angles as called for.

The completed cross-arm braces and the materials of which they are made shall conform to the requirements of the following specifications and tests.

REQUIREMENTS:

3. (a) *Finish:* All braces shall be made of a good grade of wrought iron or steel. The material shall be free from injurious seams, flaws or cracks and have a workmanlike finish.

3. (b) *Dimensions:* The braces shall correspond in all respects to the requirements of the Company's Drawings.

3. (c) *Mechanical Requirements:*

1. Tensile Strength: Flat braces shall have a tensile strength of not less than forty-eight thousand (48,000) nor more than sixty thousand (60,000) pounds per square inch.

Angle braces shall have a tensile strength of not less than fifty-five thousand (55,000) nor more than sixty-five thousand (65,000) pounds per square inch.

2. Bending Test. Flat braces or flat specimens cut from angle braces shall bend cold one hundred and eighty (180) degrees around a diameter equal to the thickness of the brace without fracture on the outside of the bent portion. The bending test may be made in the center of the braces or in the center of the larger hole. The bending test may be made by pressure or by light blows.

3. (d) *Galvanizing:* All cross-arm braces shall be well galvanized and shall conform in all respects to the Company's standard Specification

for Galvanizing on Iron and Steel. The holes in the braces shall be clean and free from superfluous zinc.

INSPECTION:

4. All cross-arm braces furnished under these specifications shall be subject to inspection by the Company at the point of delivery. Samples taken at random will be submitted to the tests hereinabove specified.

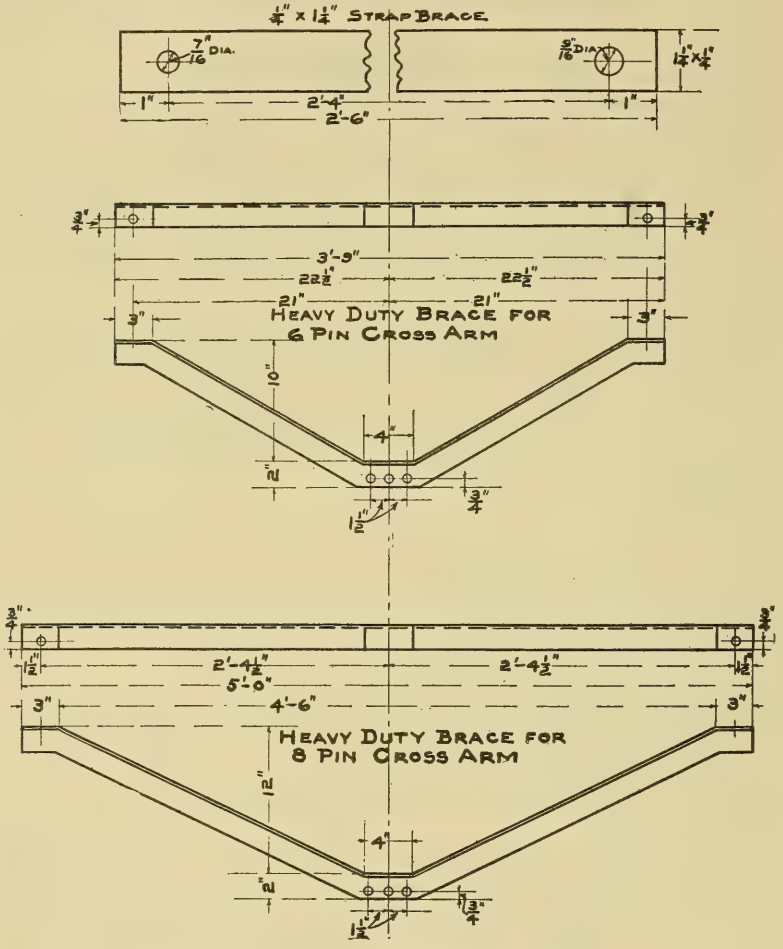


FIG. 7.—SHOWING CROSS ARM BRACES.

REJECTION:

5. Any shipment or part of a shipment which fails to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

SUB-DIVISION G

SPECIFICATIONS FOR GALVANIZED EYE BOLTS

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to or his duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or his duly authorized representative.

GENERAL DESCRIPTION:

2. The materials required under these specifications are eye bolts made of wrought iron or mild steel, galvanized.

The completed eye bolts and the materials of which they are made shall conform to the requirements of the following specifications and tests.

REQUIREMENTS:

3(a.) *Finish:* The eye bolts shall be made of a good grade of wrought iron or mild steel. The material shall be free from injurious seams, flaws, or cracks and have a workmanlike finish.

The welded joints shall be of the best workmanship, thoroughly welded without being overheated.

The threads on the bolts shall be full and clean and concentric with the axis of the bolt. The threaded end of the bolt shall be rounded or chamfered.

All nuts shall be symmetrically formed and shall have holes centrally located. The axis of the thread shall be reasonably perpendicular to the face of the nut. All nuts must be an easy fit for the bolt so that the nut can be run the entire length of the thread without undue forcing with the fingers.

All washers must be symmetrically formed and have the holes centrally located

3 (b.) *Dimensions:* The eye bolts shall correspond in all respects to the requirements of the Company's Drawing.

3 (c.) *Mechanical Requirements:*

1. Tensile Strength: The eye bolts shall have a tensile strength of not less than forty-eight thousand pounds (48,000) per square inch. The strength of the eye, nut and thread shall be sufficient to develop the ultimate strength of the bolt.

2. Bending Test: The eye bolts shall bend cold one hundred and eighty (180) degrees around a diameter equal to the diameter of the bolt without fracture on the outside of the bent portion. The bending test may be made by pressure or by light blows.

3. (d) *Galvanizing:* All bolts, nuts and washers shall be well galvanized and shall conform in all respects to the Company's standard

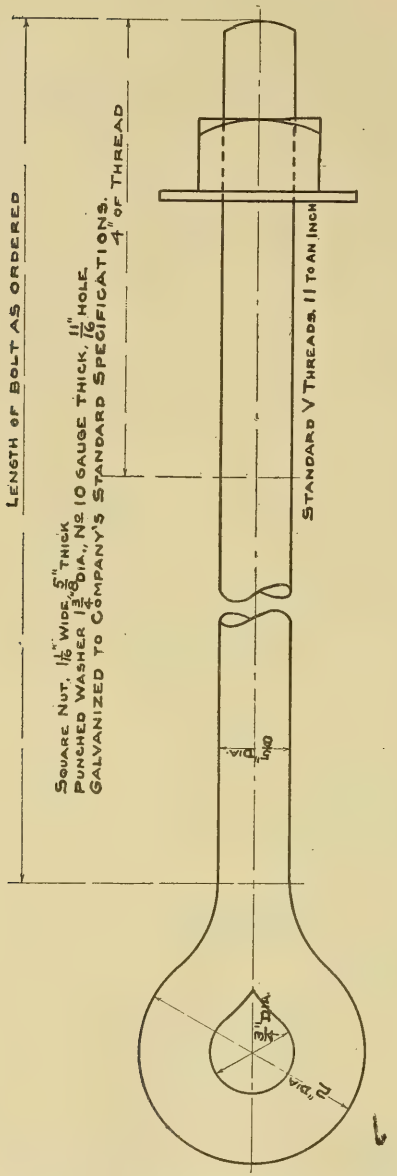

LENGTH OF BOLT AS ORDERED
SQUARE NUT, 1 1/2" WIDE, 5/8" THICK
PUNCHED WASHER 1 3/4" DIA., No 10 GAUGE THICK, 11/16" HOLE.
GALVANIZED TO COMPANY'S STANDARD SPECIFICATIONS.
4" OF THREAD
STANDARD V THREADS. 11 TO AN INCH
DIA. AT END
DIA. AT

FIG. 8.— SHOWING 5/8 IN. EYE BOLT FOR SPAN AND GUY WIRES.

Specifications for Galvanizing on Iron and Steel. The holes in the washers shall be clean and free from superfluous zinc.

INSPECTION:

4. All eye bolts furnished under these specifications shall be subject to inspection by the Company at the point of delivery. Samples taken at random will be submitted to the tests hereinabove specified.

REJECTION:

5. Any shipment or part of a shipment samples from which fail to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

SUB-DIVISION H

SPECIFICATIONS FOR HARD PINE CROSS ARMS

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The quality of material used and the methods of manufacture shall be such as to insure for the completed cross arms the properties and finish called for in these specifications. The Contractor must make sure that all material and work is in accordance with the specifications before the cross arms are delivered. All material and workmanship, unless otherwise specified, shall be of the best grade.

MATERIAL:

3. The cross arms supplied under these specifications shall be made of well seasoned, straight grained, hard pine, uniform throughout in quality. The cross arms shall be free from injurious shakes, splits, worm holes, unsound knots, or such knots as would weaken the cross arms, and other defects; cross arms having complete circular end checks will be rejected. No section of the cross arms shall contain more than 25 per cent of sap wood.

DIMENSIONS:

4. All cross arms must be dressed on four (4) sides, each square to the others, and finished to exact size, and must conform in all respects to the Company's drawing, which forms a part of the specifications. All holes must be bored from a template and no cross arms will be accepted that vary in this respect more than 1/32 of an inch either way from dimensions given, either as to location or size of holes.

INSPECTION:

5. All cross arms shall be subject to inspection by the Company at point of delivery.

FAILURE TO COMPLY WITH REQUIREMENTS:

6. Any cross arms which do not conform to the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

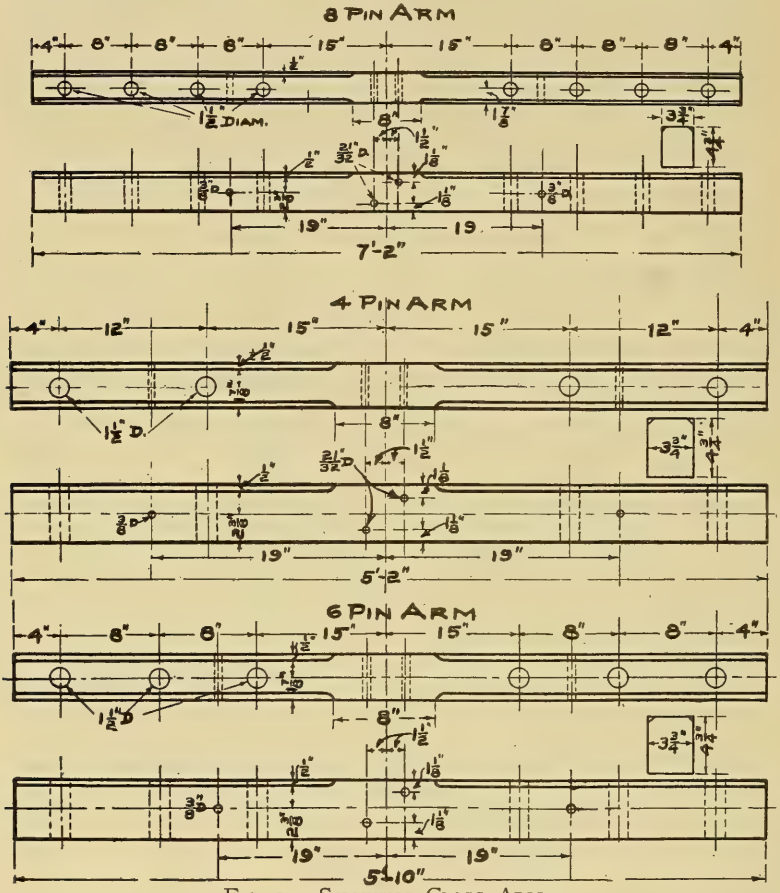



FIG. 9.— SHOWING CROSS ARM.

SUB-DIVISION I

SPECIFICATIONS FOR GALVANIZED STEEL WIRE STRAND

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or inafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The material desired under this specification is a strand of seven (7) extra galvanized steel wires twisted together to the requisite size. The wire composing the strand shall be of circular section with uniform diameter and must be free from all cracks, splints or other flaws.

MECHANICAL REQUIREMENTS:

3. Diameter of Strand (Inches)	Number of wires	Size of wires B. W. G.	Minimum tensile strength of strand (pounds)
½	7	8	8,500
3/8	7	11	5,000
5/16	7	12	3,800
¼	7	14	2,300

GALVANIZING:

4. The Company's standard specifications for galvanized material shall form a part of these specifications, and the wires composing a strand shall be galvanized in accordance with these requirements.

INSPECTION:

5. When a shipment is received samples shall be taken at random which must meet the above requirements in all respects.

FAILURE TO MEET REQUIREMENTS:

6. Any shipment or shipments which fail to pass the above requirements may be rejected and returned at the expense of the Contractor.

SUB-DIVISION J

SPECIFICATIONS FOR EARS FOR TROLLEY WIRE

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to or his duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to or his duly authorized representative.

GENERAL DESCRIPTION:

2. The material required under these specifications are trolley ears, made from smooth one piece castings free from blow-holes, and sand-holes. The completed trolley ears and the alloy of which they are made shall conform to the following requirements.

CONSTRUCTION:

3 (a.) The ears must be of clinch type shown in the drawings of the Companies, and must correspond to the drawing with respect to form and construction.

3 (b.) The lips and groove must be finished in such a manner that the ear shall fit the wire snugly and that there shall be no rough places which will interfere with the proper attaching of the ear to the wire.

3 (c.) All ears must be tapped for a standard ⅝ in. stud, and must fit such a stud snugly. The boss must contain eight (8) full threads and the hole must be countersunk slightly to allow the ears to be easily applied to the stud without danger of cross threading. The boss must contain sufficient metal so that the walls shall be in no place less than 5/32 in. thick, and the average thickness shall not be less than 3/16 in.

COMPOSITION:

4. Trolley ears of the following composition are desired:

Copper	84 per cent.
Zinc	10 per cent.
Lead	3 per cent.
Tin	3 per cent.

All trolley ears must have a composition coming within the following limits:

Copper — Not less than	84 per cent.
Tin — " " "	2.5 or over 5 per cent.
Lead — " over	4 per cent.

There must not be over 0.2 per cent of any other metal, other than copper, zinc, tin and lead.

MECHANICAL REQUIREMENTS:

5. The metal must be sufficiently ductile not to show cracks when the lips are peaned down to the wire.

INSPECTION:

6. When a shipment of trolley ears is received, it will be inspected and samples taken at random which must pass the above requirements.

FAILURE TO COMPLY WITH REQUIREMENTS:

7. Any shipment or parts of a shipment which do not conform with the above requirements may be rejected and returned at the expense of the Contractor.

SUB-DIVISION K

SPECIFICATIONS FOR No. 12 B. W. G. BARE GALVANIZED IRON CONDUCTOR WIRE

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The material required under these specifications is a bare

galvanized iron conductor. The quality of the materials used, and the method of manufacture shall be such as to insure for the completed product the properties required by the following specifications and tests:

3. The conductor shall be a galvanized iron No. 12 Birmingham Wire Gauge (0.109 in.) in size. It shall be cylindrical in form, of uniform size and quality throughout, and shall be free from scale, flaws, splits and other defects.

It shall be guaranteed that the rod from which each coil of one piece (or each piece if the coil consists of two pieces) was drawn did not contain any weld, joint or splice.

ELECTRICAL RESISTANCE:

4. The electrical resistance of the wire shall not exceed thirty-five and seven-tenths (35.7) ohms per mile, when measured at or corrected to sixty-eight degree (68 deg.) Fahr. In reducing to standard temperature a correction of 0.27 per cent. per degree Fahr. shall be used.

MECHANICAL REQUIREMENTS:

5. Size B. W. G.	Diameter over galvanizing in inches			Tensile strength (pounds)	Torsion turns in 6 inches not less than
	Desired	Maximum	Minimum		
12.....	0.109	0.113	0.105	460	15

The tensile tests shall be made upon samples of wire ten inches (10 in.) long between the holders of the machine.

The torsion tests shall be made upon samples six inches (6 in.) long between the holders of the machine.

GALVANIZING:

6. The wire shall be well galvanized and must meet the requirements in all respects of the Company's standard specifications for Galvanizing on Iron and Steel.

METHOD OF PACKING:

7. It is desired that wire be shipped in coils of one (1) piece. If this cannot be undertaken by the contractor one-third (⅓) of the coils in a shipment may have two (2) pieces to a coil joined by the ordinary twist joint, carefully soldered and galvanized. It shall, however, be stated in the bid whether there are to be one (1) or two (2) pieces in the coils.

INSPECTION:

8. When a shipment is received samples may be taken at random which must meet the above requirements in all respects.

FAILURE TO MEET REQUIREMENTS:

9. Any shipment or part of a shipment which fails to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

SUB-DIVISION L

SPECIFICATIONS FOR BARE GALVANIZED IRON SUSPENSION AND GUY WIRE

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. This wire is for use as a suspension and guy wire. It is NOT intended for the transmission of electricity.

The finished product desired under these specifications is galvanized iron wire of the sizes specified and having the properties as hereinafter described.

FINISH:

3. The wire shall be cylindrical in form and free from scales, flaws and all other imperfections. The finish of the wire shall be in accordance with the best commercial practice. Each coil shall be guaranteed not to contain any weld, joint or splice in the rod before drawn.

MECHANICAL REQUIREMENTS:

4. Size B. W. G.	Diameter (galvanized) inches			Tensile strength (pounds)	Torsion turns in 10 inches
	Required	Maximum	Minimum		
4	0.238	0.243	0.233	2500	22–30
6	0.203	0.207	0.199	1800	22–30
8	0.165	0.169	0.162	1300	Not under 30
10	0.134	0.138	0.131	900	" " 30
12	0.109	0.113	0.106	600	" " 40

4 (a.) *Tensile Strength:* The tensile test shall be made upon a sample of wire ten inches (10 in.) long between the holders of the machine.

4 (b.) *Torsion Tests:* Three torsion tests shall be made upon samples ten inches (10 in.) long between the holders of the machine and the average result taken.

GALVANIZING:

5. The wire shall be well galvanized and shall meet the requirements of the Company's standard Specifications for Galvanizing on Iron and Steel, which shall form a portion of these specifications.

INSPECTION:

6. When a shipment is received, samples shall be taken at random which meet the above requirements in all respects.

FAILURE TO MEET REQUIREMENTS:

7. Any shipment or part of a shipment which fails to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

SUB-DIVISION M

PART I.— SPECIFICATIONS FOR SINGLE CONDUCTOR WEATHERPROOF TRIPLE BRAIDED WIRE AND CABLE

DEFINITION OF TERMS:

1. The word "Company" where occurring in these specifications shall mean the purchaser of the material hereinafter referred to, or its duly authorized representative.

The word "Contractor" where occurring in these specifications shall mean the party accepting the order to furnish the material hereinafter referred to, or its duly authorized representative.

GENERAL DESCRIPTION:

2. The material required under these specifications is a cable having a copper conductor from No. 14 American wire gauge to 1,000,000 c. m. cross section, as called for in the order, covered with three (3) weatherproof braids of the required quality. See Part II of these Specifications.

The completed cable and the materials of which it is made shall conform to the requirements of the following specifications and tests:

CONDUCTOR:

3. The conductor shall consist of annealed copper wire free from splints, flaws or other defects, having a conductivity of not less than ninety-eight and one-half (98.5) per cent. of Standard Annealed Copper at 20 deg. C.

The diameter of solid conductors shall not vary from that specified in the attached tabulation by more than one (1) mil, over or under, on wires having a diameter of less than one-tenth of one inch (0.1 in.) nor by more than two (2) mils on wires having a diameter of one-ten of one-inch (0.1 in.) or larger. See Part III of these Specifications.

Stranded conductors shall consist of the number of wires specified in the attached tabulation concentrically stranded together in reverse spiral layers and having an aggregate cross sectional area when

measured at right angles to the axis of the individual wires at least equal to that corresponding to the specified size.

WEATHERPROOF BRAID AND FINISH:

4. The weatherproof braid and finish shall conform to the requirements of the Specifications for Weatherproof Braid and Finish attached to and hereby made a part of these Specifications. See Part IV of these Specifications.

WEIGHT OF FINISHED WIRE AND CABLE:

5. The weight of the finished cable desired is shown in the attached tabulation. In no case shall the weight per thousand feet vary more than two and one-half (2½) per cent. in either direction from the specified weight for that size.

SAMPLE TO BE SUBMITTED:

6. All bids must be accompanied by a sample eighteen inches (18 in.) in length of the finished wire or cable which it is proposed to furnish under this specification. In case the order calls for more than one size conductor, a separate sample shall be furnished for each size so called for. The Contractor shall guarantee that the wire or cable shipped on the order shall agree in all respects with the sample submitted.

PACKING:

7. All wire and cable shall be packed for shipment so that it will be suitably protected from injury. Each reel or coil shall be plainly marked giving the net weight of wire or cable, the size of conductor, date of manufacture and the Company's order number on which shipment is made.

FAILURE TO MEET REQUIREMENTS:

8. Any shipment or part of a shipment of wire which fails to meet the requirements hereinabove specified may be rejected and returned at the expense of the Contractor.

PART II.— WEATHERPROOF BRAID AND FINISH

DESCRIPTION:

1. The weatherproof covering shall consist of three (3) fine, smooth, closely woven braids of cotton yarn, all of which shall be thoroughly saturated with a dense weatherproof compound having the properties hereinafter specified. The impregnated braids shall be uniformly covered with a continuous layer of suitable weatherproof compound which shall adhere firmly to the braid. The outer surface shall be thoroughly slicked down.

REQUIREMENTS:

2. The weatherproof compound shall have no injurious action upon the conductor or braid, and it shall be insoluble in water. It shall be sufficiently elastic between the temperatures of forty (40) degrees Fahr. and ninety (90) degrees Fahr. so that that the completed wire

can be bent to a radius of ten (10) times its outside diameter without showing cracks in the finished surface of the wire or squeezing out of the weatherproof compound. The weatherproof compound shall be of such a nature that it shall not crack when the finished wire is subjected to a temperature of ten (10) degrees below zero Fahr., and that it will meet the requirements when the finished wire is subjected to the following:

MELTING TEST FOR WEATHERPROOF COMPOUND:

3. Short samples of the finished wire shall be placed on a piece of clean white paper in an oven and shall be subjected to a temperature of one hundred and twenty-five (125) degrees Fahr. for one-half (½) hour. The compound shall not become sufficiently fluid to form a ridge upon the paper perceptible to the fingers or, in case the compound shall be absorbed by the paper, to show a greasy or oily spot upon the paper, nor shall the comound show a tendency to flow toward the bottom of the wire, thus exposing the cotton fibre of the braid at the top.

PART III.—CONDUCTOR

Size A. W. G.	Circular (Mils)	Number of wires	Diameter of wires (Mils)	Outside diameter (Mils)	Weight of copper per M. ft. (Pounds)	Resistance per M ft. at 25° C (Ohm)	Continuous current carrying capacity (Amperes)
	1,000,000	61	128.0	1152	3090.	0.0108	1000
	900,000	61	121.5	1093	2780.	.0120	920
	800,000	61	114.5	1031	2470.	.0135	840
	700,000	61	107.1	964	2160.	.0154	760
	600,000	61	99.2	893	1850.	.0180	680
	500,000	37	116.2	814	1540.	.0216	590
	400,000	37	104.0	728	1240.	.0270	500
	300,000	37	90.0	630	926.	.0360	400
	250,000	37	82.2	575	772.	.0432	350
0000	212,000	19	105.5	528	653.	.0510	312
000	168,000	19	94.0	470	518.	.0643	262
00	133,000	19	83.7	418	411.	.0811	220
0	106,000	19	74.5	373	326.	.102	185
0000	212,000	1	460.0	.....	641.	.0500	312
000	168,000	1	410.	.....	508.	.0630	262
00	133,000	1	365.	.....	403.	.0795	220
0	106,000	1	325.	.....	319.	.100	185
1	83,700	1	289.	.....	253.	.126	156
2	66,400	1	258.	.....	201.	.159	131
3	52,600	1	229.	.....	159.	.201	110
4	41,700	1	204.	.....	126.	.253	92
6	26,300	1	162.	.....	79.5	.403	65
8	16,500	1	128.	.....	50.0	.641	46
10	10,400	1	102.	.....	31.4	1.02	32
12	6,530	1	81.	.....	19.8	1.62	23
14	4,110	1	64.	.....	12.4	2.58	16

PART IV.— WEATHERPROOF BRAID AND FINISH

Size A. W. G.	Circular (Mils)	Approximate thickness of insulation (Inches)	Desired weight per M ft. (Pounds)
	1,000,000	9/64	3550
	900,000	9/64	3212
	800,000	9/64	2886
	700,000	9/64	2544
	600,000	9/64	2150
	500,000	9/64	1822
	400,000	8/64	1490
	300,000	8/64	1125
	250,000	8/64	942
0000	212,000	7/64	771
000	168,000	7/64	631
00	133,000	7/64	503
0	106,000	7/64	408
0000	212,000	7/64	743
000	168,000	7/64	606
00	133,000	7/64	482
0	106,000	7/64	389
1	83,700	7/64	303
2	66,400	6/64	248
3	52,600	6/64	192
4	41,700	6/64	156
6	26,300	6/64	105.5
8	16,500	5/64	70.1
10	10,400	5/64	48.7
12	6,530	5/64	32.0
14	4,110	5/64	22.5

APPENDIX F

ELECTRIC WIRE AND CABLE TERMINOLOGY

1. *Wire:* A slender rod or filament of metal.
2. *Conductor:* A wire or combination of wires not insulated from one another, suitable for carrying a single electric current.
3. *Stranded Conductor:* A conductor composed of a group of wires or any combination of groups of wires.
4. *Cable:* (1) A stranded conductor (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
5. *Strand:* One of the component conductors of a cable; or one of the wires or groups of wires of any stranded conductor.
6. *Stranded Wire:* A group of small wires, used as a single wire.
7. *Cord:* A small cable, very flexible and substantially insulated to withstand wear.
8. *Concentric Strand:* A strand composed of a central core surrounded by one or more layers of helically laid wires or groups of wires.
9. *Concentric Lay Cable:* A concentric strand used as a completed cable.
10. *N-Conductor Cable:* A combination of N conductors insulated from one another.
11. *N-Conductor Concentric Cable:* A cable composed of an insulated central conducting core with (N-1) tubular stranded conductors laid over its concentrically and separated by layers of insulation.
12. *Duplex Cable:* Two insulated single-conductor cables twisted together.
13. *Twin Cable:* Two insulated single-conductor cables laid parallel, having a common covering.
14. *Triplex Cable:* Three insulated single-conductor cables twisted together.
15. *Twisted Pair:* Two small insulated conductors twisted together, without a common covering.
16. *Twin Wire:* Two small insulated conductors laid parallel, having a common covering.

PRESIDENT ACKERMAN:— The report is now before you, with the additions which Mr. Palmer has read. The first subject which the Committee desires to have discussed and disposed of is given on page 105 — Revision of Specifications for Overhead Crossings of Electric Light and Power Transmission Lines. I will call on Mr. Harvie, if he is in the house, to discuss this subject. Mr. Harvie not being present, is there any gentleman who desires to discuss this subject?

Discussion of Report of Committtee on Power Distribution.

MR. PALMER:— We have a written criticism submitted, in consequence of which the Committee made a change in the paragraph on "Location" in the Specifications for Overhead Crossings of Electric Light and Power Transmission Lines. The criticism is in part as follows:

"In looking over the report of the Committee on Power Distribution, I find that on page 107, Paragraph five, there is a suggested change in the power line crossing specifications, which provides that in addition to the poles or towers supporting the crossing span and the adjoining spans being in a straight line, that the adjoining spans shall be of such height that there shall be no lifting strain upon the supporting insulators, and I most strongly urge that this change be not made as it is written, if my interpretation of it is correct.

"Four years of experience in this kind of construction has taught me that it is a fallacy to attempt to grade up a line to meet the tower height, as it puts many unnecessary strains in a line, which it is perfectly proper to build at the normal height from the ground.

"We have several such crossings and believe that they are of the very best construction, far better than having high towers at a crossing, and, therefore, if my interpretation of your changed rule is correct, I think that it is not only inconsistent with good engineering, which opinion is based on four years' practice with such construction, but it makes unnecessary expense of construction, and a great deal of trouble of maintenance for the company doing this work."

It was the thought of the Committee in making its first recommendation, that no lifting strain should be imposed upon straight line insulators as ordinarily used, and, therefore, they made the recommendation that the pole heights on each side should be such that there would be no such lifting strain. But with special insulators and special devices for fastening, the line wires the Committee can see no reason why there should not be an abrupt change in grade if anyone considers it advisable or necessary to make it.

MR. HANNA:—As I understand, these specifications as they now stand are changed but slightly from the specifications of last year, and that they have been formally approved by the American Railway Association.

MR. PALMER:— Yes, with slight modifications of their own, I was so informed by the chairman of the Joint Committee on High Tension Overhead Wire Crossings.

MR. HANNA:— We were advised last year that they had not been so approved. Some members of the American Railway Association had serious objections to them and changes much more comprehensive than those which have been now submitted, were desired. Do I understand that the specifications have been approved, as amended in this report?

MR. PALMER:— At the meeting of the Committee on Standards the statement was made by Mr. Katté that he thought that the American Railway Association would not adopt the specifications in their present form. As will be noted on page 107, it is reported "that on May 15th, 1912, the American Railway Association presented a report, through its Committee on Electrical Working, in which was included these specifications in complete detail, and the same were approved at the Convention, and adopted by that Association as Recommended Practice." These specifications, however, as approved by the American Railway Association, contained a revision of its own, entirely separate and distinct from what is proposed here. The Committee on Power Distribution is recommending that this Association adopt as Standard the original specifications, as revised by our Committee and which have no reference to the revisions that have been made by any other body. As the case now stands, the National Electric Light Association has adopted the specifications and made certain revisions. If we take the action I propose, we shall adopt these specifications with certain revisions of our own. The steam railroad interests have adopted these specifications with a few revisions of their own.

It will be necessary, as commented on later in our report, to have a conference of these joint interests to agree on revisions of these specifications, and to harmonize the differences so that the revised specifications may be the same for each individual interest.

PRESIDENT ACKERMAN:— I presume that the members have all been over this ground and are familiar with the work

which the Committee has done. You will note in the closing paragraph under the head of Revision of Specifications for Overhead Crossings of Electric Light and Power Transmission Lines, that your Committee has recommended that these specifications, as revised by it, be adopted by the Association as "Recommended Practice," and that it be authorized to confer with the other parties in interest with a view to securing united action on the revision proposed by the Committee and the other interests.

MR. YOUNG:—If I understand this report, it is the desire of the Committee that the Association shall adopt this report and that later on, the Committee will hold a joint conference with the other interests to consider the adoption of specifications, uniform in detail, to apply to all parties in interest. With that understanding, I move that these specifications, as revised by the Committee on Power Distribution, be adopted by the Association as **Recommended Practice** and that the Committee be authorized to confer with the other parties in interest with a view to securing united action on the revisions proposed by the Committee and such other interests.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject which the Committee desires discussed is—Specifications for Overhead Crossings of Trolley Contact Wires over Railway Tracks, which appears on page 98 of the report. A discussion of this subject would be of advantage to the Committee, for it would give them information relative to the experiences and opinions of the members, and would result in mutual benefit to all engaged in the industry. (No response.)

If there is no discussion on that topic we will pass to the next subject which is entitled — Specifications for Overhead Crossings of Foreign Wires with Electric Railway Wires.

MR. SALBER:— Referring to section 39, Appendix (B), I would like to know why the minimum size of conductor should be as stated "not exceeding 5,000 volts." I do not know why No. 6 is good for one and not good for another.

PRESIDENT ACKERMAN:— I will call on the Committee for a reply.

MR. PALMER:— The Committee felt that there must be some dividing line there and a certain size of wire was necessary for mechanical safety regardless of any voltage which might be used. A break of smaller size wire, with a small voltage, would not carry the same disastrous consequence as would be the case if the voltage was higher.

MR. RICHEY:— I might say the reason why the dividing line was placed at 5,000 volts was because the telephone engineers advised us that their protective devices will take care of 5,000 volts and under, but will not provide for voltages above that; and as a good many of these foreign wires would be telephone wires and the specifications would be used in connection with agreements with telephone companies, their wishes in that matter were considered.

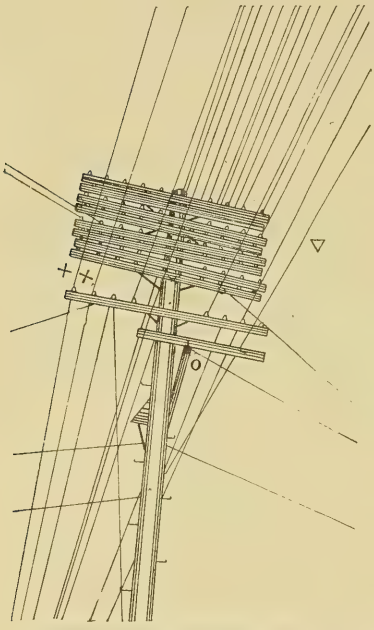
PRESIDENT ACKERMAN:— There being no further discussion on this subject, we will consider the next — Concrete, Latticed and Tubular Poles, Including Settings for Iron Poles — given on page 99 of the report. If there is no one who wishes to discuss this part of the report, we will pass to the next subject: Specifications for the Joint Use of Poles (see pages 97 and 98 of the report). You will notice that the Committee has made a definite recommendation in the last paragraph. This subject is now open for discussion.

MR. ADAMS:— Mr. Chairman, I move that the recommendation of the Committee in regard to that point be adopted.

MR. PALMER:— I am very confident that there are many members here who have some very strong ideas on this subject of the joint use of poles. Before the Committee finally leaves this matter, we would like extremely well to hear from the membership of the Association, if they have any ideas or suggestions to offer.

MR. ROBERTS:— I think it reasonable to suppose it possible to have an agreement between this Association, the American Telephone & Telegraph Co. and other interests concerned in this matter, and to my mind the important object in view and the one upon which all should focus attention is the matter of making the poles perfectly safe, not giving serious consideration to the matter of the cost of construction. The

thought should be the possibility of making pole-climbing as safe as walking on a pavement. Unfortunately we have had some sorry experiences in connection with this matter in our city during the last few months and only recently an experienced lineman was killed on our line, by coming in contact with a cable on one side of a 4,000 volt 3-phase star-connected transmission line. The sad part of it was that the man had been out of employment and probably was unable to provide himself with proper safety devices. He had a wife and five little children, all, I think, under ten years of age, and that woman and her little children have been left practically unprovided for. I only mention this as a specimen of the very many cases that come up all over the country, and want to repeat that we ought to endeavor to make the work of these men comparatively safe, though realizing that it will never be possible to put up such safeguards as will make it absolutely safe. Only a short time ago a lineman was killed at one of our stations — an experienced man who happened to put his hand on a wire, while standing by a pole. I say that we ought to give our chief consideration to the construction of our work so that men may safely attend to their ordinary business. I think the practical way out of this is to insist that we have at least 15 in. on each side clear from the center of the pole; that is, if there is a cable to be strung in connection with the transmission system or telephone or telegraph lines, that it be hung not less than 15 in. from the center of the pole, and that there



△ Messenger and Telephone Cable.
+ 2200 volt, 3 phase. The two pole pin wires are 2200 volts single phase.
O Secondary.
Man was killed just about where cross arm was marked O.

be 30 clear inches of space left for a man to climb through. While objection has been made to this plan, I have never heard sufficient reasonable objection. I think the position taken by our Committee on the matter is a proper one. Of course we feel our responsibility in the matter and we also feel that we would like to work together in an amicable way with the people who are being called upon jointly to consider these matters with us; yet, I think we ought to insist upon the position we take as being the correct one and to do all we can to protect the men who are working for the companies represented in this Association. I think the matters we have discussed previously in our meetings, here this morning, are reasonable, and I think we should insist upon the construction recommended. Nobody would object to adopting recommendations made by practical men engaged in this business, men who thoroughly understand the conditions surrounding those who are called upon to work for us, and I think everyone will agree that we ought to have the working conditions made as safe as possible.

MR. PENOYER:— During 1911 the New York Electric Railway Association appointed a committee on the joint use of poles. That committee spent the greater part of the year in drafting a form of agreement broad enough to be used by all interests. This form of agreement was finally adopted by the New York Electric Railway Association, which further recommended that the form of agreement be submitted to the American Association, with a view to having it taken up by that Association, in conjunction with the National Electric Light Association. I note in this report that Mr. Harvie was elected chairman of the Committee appointed by the American Association to consider this matter and I would inquire if that Committee has as yet accomplished any results?

PRESIDENT ACKERMAN:— I would like to have Prof. A. S. Richey, who is a member of that Committee reply to Mr. Penoyer's inquiry.

MR. RICHEY:— I might say that the Committee has done something with it. The Committee was finally appointed, I think, last June and has held three meetings at which some

work has been done on the form of an agreement, but more has been done on the matter of specifications. The Joint Committee has practically agreed upon a set of specifications and are in accord on all matters of the specifications with the exception of one thing, which has been hinted at here within the last few minutes. We might as well talk right out about it and obtain the opinion of men in this Association to take back to that Joint Committee. The position that the electric railway representatives on the Joint Committee took as to the matter of specifications, was that in general the two sides of the pole should be designated as the "face" and "back" and that the cross arms should be on the face of the pole; that all vertical attachments, such as transformers, cable distribution boxes, etc., should, on joint poles, be confined to the face of the pole, leaving the back of the pole free for climbing purposes. Then, in order to give a man room to climb up through the wires, they also took the position that on every cross arm the pole pins should be 30 in. apart, thus giving the lineman a space 30 in. wide, perfectly free, in which to climb to the top of the pole. They included in their views as well, the matter of the telephone cable. The ordinary practice of hanging a telephone cable on a telephone pole, is to hang it from a messenger wire which is attached directly to the side of the pole. The position which the railway representatives on the Joint Committee have taken is that on jointly used poles the telephone companies should be required to hang their telephone cables on a cross arm 15 in. out from the center of the pole, so the 30-in. wide space on the back of the pole, its full length, will be free and clear of all obstructions. On that point the Joint Committee is not in full agreement as some of the members feel that the telephone companies should be allowed to retain their present practice of hanging the cable directly against the side of the pole. I think that the Committee, in another meeting or two, will probably all come to some understanding on that, but as a member of the Joint Committee, I would like a discussion here on that particular point. On a jointly used pole, where every other wire including our heavy railway feeders is re-

quired to be hung out on cross arms 15 in. from the center of the pole, should we, or should we not, require telephone cables to be hung out to that same position?

MR. PENOYER:— I agree with Mr. Richey. I believe all cables should be 15 in. from the pole.

MR. BURNELL:— What argument is advanced by the telephone people that they should not be 15 in. from the pole?

MR. RICHEY:— They have not given any good argument, their stated reason is that their "standard construction" is up against the side of the pole, and that if a cross arm is placed parallel with the telephone cable and directly above the telephone cable, a man can ascend the pole with safety, by swinging out on the quarter side of the pole.

MR. COFFIN:— I feel that the telephone people show little concern beyond their own convenience, by monopolizing one side of poles with a wire fence on brackets, leaving no place for a lineman to stand with safety. It is but a short time since a lineman was killed in our town on a grounded circuit.

MR. SMITH:— I would like to ask Mr. Richey if he can tell us to what extent this matter has been gone into by the Telephone Companies and how has it been put up to them?

MR. RICHEY:— The method of taking it up is this — The American Telephone and Telegraph Company have had representatives meeting with this Joint Committee all the time and we are endeavoring to produce a specification or agreement which will be satisfactory to them.

MR. SALBER:— To what extent has the National Electric Light Association entered into this, or adopted this standard?

MR. RICHEY:— The National Electric Light Association has members on this Joint Committee.

MR. SALBER:— I am about ready to install an overhead cable and I am interested in the discussion of this question. I was wondering if the National Electric Light Association had adopted a standard or were going to adopt one.

MR. RICHEY:— I would like to correct a mistake and advise as to just who are the parties to this joint conference. They are the American Electric Railway Association, the National Electric Light Association, the American Institute

of Electrical Engineers, and with them are meeting representatives of the American Telephone & Telegraph Company.

Mr. Smith:— Not knowing just to what extent this discussion has proceeded in that Committee, perhaps the gentleman can tell us how the Committee regards these telephone messengers and cables, whether they start off by considering them as dead grounds and treating them as they would treat ground-returns and grounded guy wires, as regards their proximity to live wires. It seems to me that the relative position which live wires and ground wires should occupy on a pole, is a fair starting point for discussion. If telephone messengers and cables are treated as dead grounds, it seems to me that it would be wise to try to agree on some kind of a scheme to have them removed as far as possible from any live wires. Has the discussion been carried as far as that in the Committee?

Mr. Richey:— I might say that the standard practice of the American Telephone & Telegraph Co. is to thoroughly ground the messenger wires supporting the cable, so they must be treated as ground wires.

Mr. Smith:— In some of the reports on overhead construction made to the National Electric Light Association a year ago, was there not some specific treatment of grounded guy wires? That feature was covered in the adopted report in some way, was it not? I think it was in the Blue Book.

Mr. Richey:— That Blue Book, the report of the Overhead Line Construction Committee of the National Electric Light Association, contains specifications for poles jointly used, but it was simply included in that report as something which they had adopted as standard some years ago. The representatives of the National Electric Light Association on the Joint Committee, have told us, in so many words, that that portion of the Blue Book can be regarded as if it were not in existence.

Mr. Palmer:— I wish to say a few words on the subject. When any one is occupying his own premises, he is, to a certain extent, free to occupy them in any way he sees fit, but as soon as any premises, whether poles or any other kind, become occupied by common tenants, each tenant must so

exercise his right of occupancy that it will not interfere with similar rights of other tenants. Now, in this matter of the general occupation of the poles, it is very clear that a pole which is jointly used and occupied must have its attachments made, to a large extent, in a different manner from what they would be, if the pole was occupied solely by the owner. The cardinal principle, on which the joint use of poles is based, is that each occupant of the pole must have free and uninterrupted climbing space through and by the wires or attachments of the other tenants. To that extent, wires and attachments of one company should not be allowed to be so placed as to defeat the great principle which we have in view in this joint use of poles, and which makes such joint use practicable. Now, to those of us who are practical linemen, who have had the spurs on our legs, who have climbed poles and been up alongside these deadly wires, it seems that there can be but one side to this question. Take the case of the joint occupation of a pole by an electric light company and by a railway company. The railway company in the occupation of its own poles strings telephone and signal wires frequently on brackets attached directly to the poles, and where only one feed wire is used, it is also often attached directly to the brackets, within a few inches of the pole. Now, we come to a combination where the same pole is used by an electric light company and by a railway company. All the attachments of the railway company, which were formerly supported by brackets or otherwise, are removed from the pole and put onto a cross arm and all feed wires must be carried on cross arms and at a certain distance from the pole. Electric light companies have never taken any other position but that their wires should be supported on cross arms at least 15 in. away from the center of the pole. Now, we have an electric light pole occupied by a light company and a railway company. Stand under the pole and look up and you will see a free climbing space at least 30 in. wide, straight up that pole through the wires for linemen to use for climbing — nothing could be better. But along comes a third tenant, the telephone company, and it says, in effect, "This free and uninterrupted

climbing space that you have, this beautiful pathway, you must give up. You cannot have that any longer. We must be allowed to interrupt it with our cable. We are going to attach it directly to the pole. It makes no difference how much inconvenience it is to you people, how dangerous it is to your linemen; though lives may be sacrificed, we must have that cable attached directly to the pole, because it is *our* standard practice." Further, the statement was made that because the telephone cables were so extremely heavy it was impractical to carry them on a cross arm. That statement was disposed of at once by showing that a 500,000 or 1,000,000 c. m. cable weighed far more than any telephone cable we know anything about, and the railway companies were carrying six to eight wires of that character, on one cross arm. The next objection was, "It is impractical, we cannot do it." The answer to that was, "There are miles of this construction already in existence, and further, wherever you want to dodge trees, if you want to hang cables on cross arms, you do so." The State of California, after extended consideration of this subject, prohibited by law the attachment of wires of any description to the side of a pole occupied by another company. Argument was made that the telephone cable was to be attached above the railway wires and the railway men had no reason for climbing to the cross arm above the cable. In all cases, where poles are jointly owned, the custody or care of the pole is allotted to one of the owners. In the case of a jointly occupied pole, occupied by three tenants, the railway company may have charge of that pole, and may have occasion to travel all the way up and down. The Telephone Company very carefully insists that a guy wire attached to the pole must not by any means carry any ground potential up to the pole, and within reach of the linemen; that strain insulators must be inserted in a guy wire, so when a lineman reaches out and his hand comes in contact with it, he will not come in contact with the ground potential and be in danger of losing his life. Nor in any other manner must unprotected ground potential be present on the pole and accessible to the lineman. While insisting on that they ground their cables, and these cable sheaths in some cases carry large currents, are attached directly

to the poles. "Consistency, thou art a jewel" absent in this proposition.

PRESIDENT ACKERMAN:—Are you ready for the question? It is moved and seconded that the recommendation of the Committee on Power Distribution regarding further consideration of the subject of Joint Use of Poles be adopted.

(The motion was put to vote and carried.)

PRESIDENT ACKERMAN:—The next subject, gentlemen, is on page 99 of the report, High Grade Rubber Insulating Compound, and is now before you for discussion.

MR. PHILLIPS:—In this matter of rubber insulation there seems to be some misunderstanding between the Committee on Equipment and the Committee on Power Distribution. Equipment engineers are not particularly interested in drawing up specifications for thirty per cent. Para rubber, although the Committee on Equipment did review a recommendation contained in the 1911 report of the Committee on Power Distribution, and found it satisfactory.

Equipment engineers are interested in high grade compound insulation, and in the construction of wires and cables for cars. I think, however, that the specifications for insulating compound itself might well be referred to the Committee on Power Distribution.

MR. PALMER:—I have a written discussion here from Mr. C. F. Woods, on the subject of 30 per cent. Para rubber compound. Before I read it I will say a word or two on the subject. I think myself that the change of name, from 30 per cent. Para rubber compound to high grade insulating compound, was, perhaps, a mistake. The words "30 per cent. Para rubber compound" represent a certain definite material, as known to the trade and to the industry. The words "high grade rubber compound" may mean anything or may mean several grades of rubber, all of which are high grade. The Committee on Power Distribution has an interest in a rubber insulation of a lower grade than that obtained by the use of 30 per cent. Para, and where the Committee on Power Distribution and the Committee on Equipment have an insulation of the same grade under consideration, we should be very glad to collaborate with them.

Written Discussion by Mr. C. F. Woods.

In the past year there has been a marked advance in our knowledge of rubber insulation and proper specifications for guaranteeing a suitable compound. There are at present engaged on the work of rubber analysis and specifications three important Committees. The first and most important, the so-called Railroad Committee which was called together by Mr. Katté of the New York Central and Hudson River Railroad, consists of railroad engineers and chemists, manufacturers and independent experts. This Committee has made an exhaustive investigation of rubber insulation specifications and is about ready to report its findings. The report will contain detailed specifications for 30 per cent compound and carefully worked out methods of analysis and tests by which the desired qualities may be estimated. The make-up of this committee and the character of work which they have accomplished insures a report of far greater importance than any previous or pending report of any committee.

The second committee is that of the American Chemical Society composed of chemists from both producing and consuming interests who have been actively engaged in standardizing methods of chemical analysis for rubber compounds, a subject which up to this time has been chaotic.

The third committee is that of the American Society for Testing Materials composed in accordance with their fixed custom of equal representation of producers and consumers. This committee has a somewhat wider scope than the other two as it will include all kinds of rubber compounds used commercially. Fortunately, the make-up of these committees is such, due to the individual representation on two or more of the committees, that all three are working in close harmony and are not unnecessarily duplicating the work of others.

It may safely be said that the investigations up to date have clearly shown the necessity of careful and complete chemical analysis of rubber insulation in addition to mechanical and electrical tests in order to check the fulfillment of specifications. The collection of data and the individual knowledge of rubber compounds embodied in these committees renders

the forthcoming report of unusual value and I feel very strongly that our Association would be making a serious mistake in taking any further steps toward specifications for 30 per cent. compound until the report of the Railroad Committee is ready for our consideration. This statement is made without prejudice toward the findings of this Committee. It may be that your Association will justly differ from their conclusions, but the fact remains that this report will embody so extensive and thorough an investigation that no association can afford to take action on this important subject without having carefully considered the data and recommendations of this group of men.

The necessity of chemical analysis has been increasingly apparent to all who have been studying this subject, and, owing to the lack of scientific knowledge about rubber and its compounds, an extraordinary number of inaccurate methods are being used for determining the essential characteristics of insulation. It is of the utmost importance, therefore, that any specifications of far reaching importance, such as those adopted by your Association, should embody the latest and best information on this subject, and this can be done the quickest and most accurately by awaiting the report.

If we may be allowed a suggestion, it would seem desirable that the Committees of your Association which have this matter in charge should immediately co-operate to the fullest extent with the above mentioned Committees, in order that there may be no needless duplication of work, and also in order that the several associations now engaged in this important matter should have their fields of investigation carefully marked out so that all of the essential features will be properly considered without necessitating unnecessary work.

It is unfortunately true that the investigation of this subject has shown that our previous specifications cannot be simplified but must be amplified to a very great extent and include a number of tests and carefully described tests which they have not hitherto done. It is particularly encouraging that the large manufacturing interests have shown a decided change of heart and utmost willingness to give to the several associa-

tions all of the information in their possession and to co-operate to the fullest extent on the adoption of thoroughly standard requirements.

SECRETARY LITCHFIELD:— There has been considerable discussion about the question whether the matter should be handled entirely by the Committee on Power Distribution, or in conjunction with the Committee on Equipment. The majority of the equipment men of the country possibly are not interested in 30 per cent Para rubber, but there are some roads, including the one with which I am connected, who do use it exclusively on cars, and I therefore believe the matter should receive the attention of the Committee on Equipment, as well as that of the Committee on Power Distribution.

MR. ADAMS:— To my mind, the best way of disposing of this question is to leave the matter in the hands of the Executive Committee for final decision. I think Mr. Palmer's recommendations applying to that Committee are thoroughly in order.

PRESIDENT ACKERMAN:— Gentlemen, you have heard the motion. It is moved and seconded that the recommendations of the Committee regarding High Grade Rubber Insulating Compound be adopted.

(Motion put and carried.)

PRESIDENT ACKERMAN:— The next subject for consideration is Standard Stranding Tables (see page 101 of the report).

MR. ADAMS:— In connection with this particular question it is only right that it should be stated in advance of the meeting of the Committee on Standards, that this Committee has approved this particular recommendation. I say this for the information of the members present, and if it is approved by the Association in Convention it will then be forwarded to the Executive Committee of the American Association in the usual manner.

MR. COFFIN:— I move that the recommendation of the Committee, namely that the Standard Stranding Table, which is based on our present Standard Copper Wire Table be adopted as standard.

(Motion duly seconded and passed.)

PRESIDENT ACKERMAN:—The next matter is Tables given at the top of page 102 of the report. Is there any discussion on this subject?

MR. ADAMS:—If I may state the action of the Committee on Standards in connection with this matter as it may be of value to the members. The Committee on Standards referred this subject back to the Committee on Power Distribution, in order that the working table might be complete. It is now complete and if the Association adopts this recommendation, it will then go back to the Committee on Standards for its action, which will undoubtedly be one of approval.

MR. DATZ:—I move that the revised Copper Wire Tables be approved as **Standard.**

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:—The next subject for consideration is that of Trolley Guards referred to on page 103 of the report.

MR. ADAMS:—Perhaps if I give an outline of the action of the Committee on Standards on this particular question it may be of interest. The Committee on Standards did not approve this recommendation of the Committee on Power Distribution, as it was considered to be a subject which will be taken up in connection with other standard overhead work. It is not a subject for a recommendation of the Committee on Standards in this connection.

MR. BURNELL:—We have been using these Trolley Guards in Houston for some little time. It is, of course, necessary for us to use everything possible to reduce the hazard at railroad crossings. We have installed some 20 or 30 of these crossings in the last two or three years, and thus far have but one objection, and that is that the considerable weight of these trolley guards causes the trolley to gradually lower and sometimes reduces the clearance to less than the required 22 ft. On the other hand, this 22-ft. clearance, as required by the railroads whose tracks we cross, makes it very difficult in some cases for the trolley poles to reach the trolley and small defects in the trolley bases very often cause the trolley to leave the wire. We find that the introduction of the trolley

guard has reduced the trouble to a very great extent. There has been no case of collapse, and in Houston, we think it is very successful. Therefore, I make a motion that the recommendations of the Committee regarding trolley guards be not adopted.

(The motion was duly seconded.)

MR. SCHREIBER:— May I inquire if trolley guards are not included in the standard specifications for overhead crossings?

MR. PALMER:— They will form a part of the standard specifications, and we hope to have specifications regarding the crossing of these trolley wires over steam railroad tracks agreed to by both the steam railroads and ourselves. This is but one phase of the construction which will be referred to in those specifications.

MR. PAGE:— It must be granted where the track and wire are in perfect line the necessity for trolley guards is very much reduced, but not done away with, for quite frequently the trolley wheel will jump on the straight line with no apparent cause. It seems to be commonly understood that on account of the creeping of the rails in the steam railroad, it is very difficult, if not practically impossible, to maintain a perfect alignment of track. This creeping is caused by the expansion by heat, and on double track roads, where trains run in but one direction on each track, the rails creep in the direction of the traffic. This throws one crossing frog one way and the other in an opposite direction, and causes a car in crossing to sway. The trolley wire being higher on the crossing than on any other part of the system, the trolley pole is nearer vertical, the tension is less and, therefore, a slight swaying of the car will cause the wheel to leave the wire. On our system, which I believe to be a representative one, it is not an uncommon occurrence for a trolley base to become dry, so that it swings hard, and the nearer vertical the pole, the greater the force that must be applied to swing the pole.

As to the extra hazard, due to the increased number of wires at the crossing, I agree with the Committee that the number of wires should be reduced as much as possible. The Committee recommends, however, in paragraph 8, on page 112, in

its report that on spans under certain conditions catenary construction should be used. By the installation of a suitable trolley guard I see no reason why it is not possible to secure a construction equivalent to the catenary, the only difference being the addition of a guard. I have just completed the installation of a 75-ft. section of a guard, using but one additional wire.

Any disadvantages that there may be in installing the guard are more than made up by the advantages received from its use. In this statement I am supported, so far as I know, by the Railway Commissions in every State, and particularly in New York, Ohio, Illinois, Wisconsin and Michigan, before whom I have personally appeared.

Within the last few months the Baltimore & Ohio Railroad Co. appointed a special committee to investigate the subject of protection to trolley cars crossing steam railroads at grade. The Committee went so far as to develop a set of standard drawings for the installation of a suitable trolley guard. This same question has been taken up by the Michigan Central Railroad Co. and various other steam roads, all of whom decide that the advantages to be gained by the use of the guard were of great value in preventing accidents.

It is very noticeable that the Committee finds no fault with the operation of the guard, merely the extra hazard which they think is introduced by the additional guy wires. In conclusion, I wish to say that it may not be a common occurrence for the trolley wheel to jump at the steam railroad crossing, but I believe there is not one man here that will say that it never does jump, and it is for protection at this time that the guard is installed.

It has been our experience that regardless of the efficiency of the device, the mere fact that a company has taken steps to guard against accidents has great weight with a judge or a jury when deciding an accident claim.

MR. PALMER:— I would like to close the discussion on this particular topic by stating that the steam railroads are not by any means a unit on this proposition. We have a steam railroad representative on our Committee, who is connected with

the New York, New Haven & Hartford Railroad, and the Committee considers itself in a position of being well advised through such representation on the Committee. The Committee realizes there are two sides to this matter, and the question is: What is the weight of the evidence, and, to a very large extent, what are the local conditions? Of course, we may insert in our report as recommended practice, or as a standard, a method of construction contrary to what a public service commission in some one state may require. But on the other hand, the public service commissions in many states, I believe, will be guided very largely in their decisions by the conclusions reached by this Association. The Railroad Commission of Massachusetts is often held up as a model commission of its kind. It has under its inspection constantly the steam railroad crossings, periodical inspections are made and there never has been a request to my knowledge from the State Commission of Massachusetts to have any of these guards installed. There certainly has not been a request made on our company, which operates a thousand miles of track with 111 (one hundred and eleven) crossings at grade. Nor have I seen any case on a steam railroad crossing where one of these trolley guards would have been of benefit to us. It has been our view, and the view of people in that part of the country, that the additional hazard would be greater than the benefit which would be obtained by it. In making our high tension line crossings, I remember that there were many crossings over the New York, New Haven & Hartford Railroad's private right of way, the conditions of which were such that the road could dictate the manner of the crossing, and the cardinal principle which they observed, in relation to these crossings, was to put up nothing, on the crossing, except what was absolutely necessary — their idea was to make the construction strong and safe and reduce it to the lowest possible limit. As a consequence, they would allow absolutely nothing but the line wires of the transmission line to cross their track. Nothing in the way of protection against falling wires was allowed over any of these crossings.

Mr. Thompson :— On our system, in Ohio, where we operate some 650 miles of main line, we have been asked by the

steam railroads to put up trolley guards at grade crossings. We have persistently refused to do so, believing that the hazard added by such a construction would over balance any possible benefit. In the State of Ohio there is a statute which prohibits the construction of any wire other than the trolley wire, closer than 25 feet to the track, so that I believe the construction of such a device in Ohio is contrary to law. (Sections 3365–28, Ohio Laws.)

The liability of dewiring the trolley pole at railway grade crossings is greater with single truck cars than double truck cars, but unless the crossing track is very badly out of line there is little danger of dewiring the trolley due to the bad condition of crossing frogs. I am sure it would be much safer and better if it were insisted that the crossing tracks be kept in good line and good surface, which would not only prevent the dewiring of the trolley pole, but also render much less liable the derailment of the cars themselves.

I do not know personally of any trouble with the overhead trolley guard, but I understand from the experience of the Cincinnati Traction Co. that they have not proved to be satisfactory in Cincinnati. In sleet storms they become loosened and drop below the clearance required by law and the wires have been torn down by the railroad equipment coming in contact with them.

There is another important feature of the case to be considered, and that is, that all interurban cars are equipped with trolley retrievers — and they must of necessity, have a device of that sort — so that in the case of the interurban car if the trolley pole be dewired, it will immediately be drawn down by the retriever and thus the trolley guard would not serve and cannot serve the purpose for which it is supposed to be put up for. I cannot see any excuse at all for the existence of a contrivance of that sort, except possibly in the case of a city service, where single truck cars are operated over railroad crossings. It should also be borne in mind that it is the invariable rule and practice to stop all electric cars at railroad crossings, then the conductor of the car goes ahead to the crossing and flags his car across when the way is clear. The momentum of

the car at starting may be depended upon to carry the car across the railroad track, but if the trolley should come off for any reason, the conductor is in a position to see it at once and replace it on the wire.

MR. ROBERTS:— You will note that the recommendation of the Committee reads: "Trolley Guards should not be used, except possibly in unusual cases due to complicated alignment of the crossing track." I have been interested in what Mr. Thompson has told us, but he may not be aware of the fact that the Railroad Commission of Ohio is now compelling us to put up trolley guards for all classes of service.

MR. THOMPSON:— I did not know that.

MR. ROBERTS:— We all realize when we buy a preventive of this kind, as in buying machinery, whether it is an automobile, a donkey engine or any other kind of machinery that we are buying trouble. The thing to do is to buy that which will do the work and give the least amount of trouble. We have been compelled to put these overhead guards in operation, but, in my opinion, it would be better not to use them although in our case we have a number of crossings where it is simply impossible to keep the tracks in alignment. What is needed in this case is co-operation between the steam and electric railways, each agreeing to keep the tracks and overhead construction at the crossings in the best possible condition, but that co-operation is difficult to procure, and because of such conditions we would not be warranted in saying we could dispense with the use of the trolley guards at certain crossings. I am free to say this, however, if it were possible to keep everything in good condition, ground work and overhead work, I would not think of using the trolley guard. Where a trolley guard can be put in so that it is not materially affected by locomotive smoke and steam (which would have a disastrous effect on the trolley guard if the locomotive stood directly under it) or by snow and sleet, I think that trolley guards could be satisfactorily used. If, however, the trolley guard is subject to such adverse conditions such as outlined, more or less trouble would be the result.

The consensus of opinion of the Committee was, that it is not good practice to use trolley guards where their use could

be avoided. So far as we are concerned in Ohio we have been ordered to put the trolley guards in service, and we are now equipping all of our crossings.

MR. THOMPSON:— I would suggest then that it would be well for this Association to let the Railway Commissions take the responsibility of their construction. The companies will have to comply if they are ordered to put them up, but the responsibility will rest with the Commissions. I think it would be unwise, however, for this Association, believing that trolley grades are not desirable, to go on record as recommending them in any case, because it would be construed as applying to all cases, irrespective of what the alignment of the track may be.

MR. ARCHIBALD:— I want to add a few words to what Mr. Burnell said in regard to trolley guards. We have one guard, made of solid copper, something over 300 feet in length, which crosses about eight tracks in one of the yards of the Southern Pacific Railroad Company. It has been installed a little over three years and the total maintenance has been less than $50. The height of the trolley has been inspected regularly every two months, during the time the guard has been up, and on one occasion it was found to be one inch below the standard. Our company is equipping as fast as possible every railroad crossing which we have and we find that the effect on the general public is the very best. The public is interested in them. They are anxious to see them installed, and we have had requests for information as to when we would put up trolley guards on certain crossings. I have been standing on the sidewalk and have seen cars on a crossing, when the trolley would jump the wire, and a bystander who did not know me remarked as to a friend: "See what that thing up there does — it is the best thing the company ever put up. If it had not been for that appliance the car would have been stopped on the crossing." I mention that incident to show the interest of the public in the matter. The public realizes that a grade crossing on a steam railroad is one of the greatest hazards we have to contend with. The conditions in our section of the country are

a little worse than they are in the east. In Houston we have something like 70 or 75 miles of track with 59 crossings.

The point has been raised that if the track is maintained in good condition trolley guards are not needed. We grant that, but how many railroad crossings are maintained in good condition? How many street railroads can get a steam railroad to keep the crossing in good condition. I remember one instance where a steam railway worked on a crossing, and after they had finished with it it was worse than before.

MR. SCHREIBER:— Putting the cost of maintenance at $50 for three years is hardly fair, because there will come a time when the trolley guard must be renewed. So you should add a yearly renewal charge to get the true maintenance cost.

MR. BURNELL:—As to the cost of trolley guards, we find the cost is about $3.00 per foot, and on a single track crossing it is not necessary to install over 100 ft. The cost would be comparatively small with most systems.

Mr. Thompson brought up the point regarding retrievers. If the trolley leaves the wire with sufficient jump to cause the retrievers to work, the trolley guard would be of no value whatever.

MR. SCHREIBER:— Three hundred feet of trolley guard at $3 per foot would be $900, and if the trolley guard lasts ten years, that would make an annual renewal charge of $90 which must be added to the cost of repairs of the trolley guard.

MR. ARCHIBALD:— I want to state further that the guard mentioned which we put up about three years ago shows no sign of deterioration at the present time. It is hardly safe to assume, at the present time, what the life of that guard will be. Mr. Schreiber's assumption of ten years' life for the guard is not by any means a certainty — it may last a good deal longer and probably will.

PRESIDENT ACKERMAN:—Vote will be taken now, it being understood that only delegates are entitled to vote. The recommendation of the Committee is as follows: "Trolley guards should not be used, except possibly in unusual cases

due to complicated alignment of the crossing track." The motion is that the recommendation of the Committee be not approved. I think that is clear in your minds.

(The motion was put and resulted in a tie vote.)

MR. LITCHFIELD:— I will call for a vote by roll call.

The roll was then called and the following members voted in favor of the motion:

Northern Ohio Traction & Light Company, W. E. Salber.
Houston Electric Company, W. V. Burnell.
Galveston Electric Company, W. M. Archibald.
Denver City Tramway Company (The), Norman Read.
Aurora, Elgin & Chicago Railroad Company, E. F. Gould.
Pittsburgh Railways Co., Henry Meyer.
Public Service Railway Company, E. J. Dunne.
Western New York & Pennsylvania Traction Co., W. K. Page.
Maryland Electric Railways, (The) D. E. Crouse.
Total 9.

The following members voted against the motion:

Waterloo, Cedar Falls & Northern Railway Company, G. A. Mills.
Ohio Electric Railway Company, Gaylord Thompson.
Mobile Light & Railroad Company, S. M. Coffin.
Evansville Railways Company, T. R. Crumley.
Indianapolis Traction & Terminal Company, Edward Hayden.
United Railroads of San Francisco, W. T. Bivins.
New Orleans Railway & Light Company, L. C. Datz.
Fonda, Johnstown & Gloversville Railroad Company, John Sibbald.
Bay State Street Railway Company, G. W. Palmer, Jr.
Total 9. Tie vote.

PRESIDENT ACKERMAN:— The vote is a tie. I vote against the motion. The motion is declared lost.

MR. COFFIN:— I move that the recommendation of the Committee with regard to trolley guards be adopted.

MR. LITCHFIELD:—This is an important matter—it is either wrong or very nearly right, and on account of the closeness of the vote, is it well to put the Engineering Association quite so strongly on record? This is a subject which affects very closely the interests of the member companies. There appears to be a very close division of sentiment, and in my opinion it would be wiser not to take definite action on the matter at this time, in view of the closeness of the vote.

PRESIDENT ACKERMAN:— The motion that was lost was that the Committee's recommendation be not approved. I think that, in view of the vote being so close, it would be, perhaps, to the interests of the Association to let the matter remain as it is.

MR. ARCHIBALD:— I move that the subject be referred back to the Committee on Power Distribution.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject is the Revision of Specifications for High Tension, Three Conductor, Paper Insulated, Lead Covered Cables, and the Committee's recommendation is that no further revision be made of these specifications.

MR. RICHEY:— The Committee's recommendation is not only that, but also that some changes, which they recommend, be made. I call your attention to the fact that there is nothing very vital in these changes; it is simply a matter of form.

MR. THOMPSON:— I move that the recommendation of the Committee regarding the Revised Specifications for High Tension, Three Conductor, Paper Insulated, Lead Covered Cables be adopted.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject is Revision of Specifications for Single Conductor, Paper Insulated, Lead Covered Cable for 1,200 Volts.

MR. RICHEY:— The same remarks apply to this subject as to the previous one. I move that the Revised Specifications for Single Conductor, Paper Insulated, Lead Covered Cable for 1,200 Volts be adopted.

(On motion duly made and seconded, the recommendation was adopted.)

PRESIDENT ACKERMAN:— The next subject is Specifications for Trolley Wire.

MR. RICHEY:— As the Committee is doing further work on that subject, I move that the recommendations of the Committee in that respect be adopted.

(Motion duly seconded, stated and passed.)

PRESIDENT ACKERMAN:— The next subject is Standard Sections of Grooved Trolley Wire.

MR. RICHEY:— I believe there are no recommendations, simply an elaboration, bringing out the details of previous reports.

MR. PALMER:—The report states that the Committee on Standards in its report has recommended that the present **Standard** drawings be replaced by the drawings submitted. Notwithstanding that the report has been acted upon by the Committee on Standards, you should either approve or disapprove of the report of the Committee.

MR. RICHEY:— I move that the action of the Committee regarding standard grooved trolley wire sections be approved.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject is Standard Line Material and Construction. The Committee reports progress, and in the third paragraph of this section of the report, recommends as Standard certain Specifications for Galvanizing on Iron and Steel.

MR. RICHEY:— I move that the Specifications for Galvanizing on Iron and Steel be adopted as **Standard.**

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject which we shall act on is Electric Wire and Cable Terminology, on page 111. The Committee makes a recommendation in the last paragraph.

MR. RICHEY:— I move the recommendation of the Committee be approved, and that the Electric Wire and Cable Terminology be adopted as **Standard.**

(Motion duly seconded, stated and carried.)

SECRETARY LITCHFIELD:— I recommend that a special vote of thanks be given to the Committee on Power Distribution, as I am well acquainted with the labors of the Committee — they have performed a wonderful piece of work. I move that they be tendered a vote of thanks.

(Motion duly seconded, stated and carried.)

On motion, moved and seconded, the meeting adjourned until 9:30 o'clock Tuesday morning.

TUESDAY MORNING SESSION

October 8, 1912

JOINT MEETING OF TRANSPORTATION AND TRAFFIC AND ENGINEERING ASSOCIATIONS, BROWN ROOM, SADDLE AND SIRLOIN CLUB.

President Ackerman, of the Engineering Association, called the meeting to order with Vice-president Hegarty, of the Transportation Association jointly presiding.

President Ackerman:— Gentlemen, the report before you this morning is that of the Joint Committee on Block Signals for Electric Railways; this Committee, as you know, is a joint committee of the Engineering Association and the Transportation and Traffic Association. I will call upon Mr. Waldron, chairman of the Committee, to present the report.

Mr. Waldron:— Mr. President and gentlemen, your Committee last year found that there was no general system of signal indications. Neither the companies nor the manufacturers had a certain indication maintaining any uniformity. Your Committee believed, therefore, that the most important thing that it could do would be to decide upon a system of aspects which could be universally used. This would be of some help to the railroads because it would have a tendency to cheapen signal installations, and it would also assist the manufacturers, as they would not need to carry a large number of different parts in stock.

REPORT OF THE JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS

To the American Electric Railway Engineering and the American Electric Railway Transportation and Traffic Associations:

Gentlemen.— Your Committee was instructed by the Executive Committee of the two Associations to continue the study of signaling instructions and methods and make recommendations as follows:

1. For signaling single-track suburban railways for headway between 5 and 30 minutes and speed not exceeding 20 miles per hour.

2. For signaling single-track interurban railways for headway between 1 and 10 minutes and speed not to exceed 30 miles per hour.

3. For signaling single-track interurban railways for headway not less than one hour and speed between 40 and 60 miles per hour.

4. For signaling single-track interurban railways for headway as frequent as 15 minutes with trains in several sections and speed between 40 and 60 miles per hour.

5. For signaling double-track interurban railways for headway as frequent as five minutes and speed between 40 and 60 miles per hour.

Your Committee has held four meetings. The first was held in New York City on Thursday, January 25, 1912, and all the members of the Committee were present.

The second meeting was held in Chicago March 19, 1912, all members of the Committee again being present. In addition, there were present on invitation of the Committee the following engineers and representatives of signal manufacturers: W. W. Salmon and W. K. Howe, General Railway Signal Co., Rochester, N. Y.; L. Frederick Howard, H. W. Griffin, and Harold McCready, The Union Switch & Signal Co., Swissvale, Pa.; J. J. Hubbard, Federal Signal Co., Albany, N. Y.; Carl P. Nachod, Nachod Signal Co., Philadelphia, Pa.; and John J. Ruddick and J. W. Putman, United States Electric Signal Co., West Newton, Mass.; M. H. Hovey, Consulting Signal Engineer for the Railroad Commission of Indiana and Safety Service Expert for the Railroad and Tax Commission of Wisconsin. L. E. Gould, Western Manager of the *Electric Railway Journal;* and A. D. Cloud, Editor of *The Signal Engineer* were also present. Mr. Gould acted as secretary of the meeting. At this meeting there was a general discussion on signal aspects.

The third meeting was held in Rochester, June 14 and 15, 1912. There were present at this meeting C. H. Morrison, John Leisenring and J. M. Waldron of the Committee; W. H. Howe and H. M. Sperry, General Railway Signal Co.; H. W. Griffin, The Union Switch & Signal Co.; L. E. Gould, *Electric Railway Journal;* and A. D. Cloud, *The Signal Engineer.* Mr. Cloud acted as secretary of the meeting.

The fourth meeting was held at Buffalo, July 27, 1912. There were present Mr. Emmons and Mr. Waldron of the Committee; L. F. Howard and H. W. Griffin, The Union Switch & Signal Co.; W. K. Howe and H. M. Sperry, General Railway Signal Co.; L. E. Gould, *Electric Railway Journal;* and A. D. Cloud, *The Signal Engineer.* Mr. Cloud acted as secretary of the meeting.

The Committee work was subdivided as follows:

1. Mr. Waldron was assigned the work of bringing the progress report on signaling up to date;

2. Mr. Emmons was given the Data Sheets and the bibliography on electric railway signaling and allied subjects, with instructions to bring the same up to date;

3. Mr. Conn was assigned the collection of data regarding rulings of the Interstate Commerce Commission and the various state railway commissions;

4. Mr. Morrison and Mr. Waldron were given the general subject of standards for signal indications and aspects;

5. Mr. Leisenring and Mr. Merwin were appointed a Subcommittee to confer with the signal companies and report as to their findings and recommendations with respect to the proper methods of solving the signaling problems presented in the instructions of the Executive Committees.

The Committee has kept in close touch with the work of the Railway Signal Association, which in the early part of 1912 appointed a special Committee on Signaling Requirements of Electric Railways, consisting of those members of this Committee who are also members of the Signal Association, viz., Messrs. Morrison, Leisenring and Waldron. Mr. Waldron also being chairman of this special Committee. The outline of work proposed by the Board of Direction of the Signal Association authorizes the Committee to bring to the attention of the other committees the peculiar requirements and conditions of electric railway operation that should be taken into account in their work, and to recommend such changes in the standards and recommended practices of the Signal Association, together with such amendments to the conclusions of the other committees as may be found necessary to meet the peculiar requirements and conditions affecting signaling on electric railways.

DIGEST OF BLOCK SIGNAL LAWS AND RULINGS

A bill intended to convey full authority upon the Interstate Commerce Commission, the full text of which was printed in last year's report (pages 193–198, 1911 Engineering Association Proceedings) to require block signals on roads engaged in interstate commerce, has been introduced in each session of Congress since 1903, and was last introduced by Representative Esch in the House of Representatives on April 5, 1911. This bill, known as the Esch Bill, H. R. 1668, is still pending in the House of Representatives.

The following states have no laws or commission rulings bearing upon the subject of block signals, with the exception of crossing protection, although some of the states have statutes governing interlocking:

Colorado.	Connecticut.	Florida.
Iowa.	Maine.	Michigan.
Nevada.	Nebraska.	New Hampshire.
New Jersey.	New Mexico.	North Carolina.
Oklahoma.	Pennsylvania.	Texas.
Virginia.	Washington.	Wyoming.
Louisiana.	Georgia.	Oregon.
Illinois.	Kansas.	Missouri.
North Dakota.	Vermont.	Wisconsin.*

* A Wisconsin law in effect but not included in this report is shown in page 292 of this volume.

The railway commissions in Arkansas, Kentucky, Mississippi, Montana, Ohio, Rhode Island, South Carolina, South Dakota and Tennessee have no jurisdiction over electric railways insofar as block signaling is concerned.

The States of Idaho and Utah have no railroad or public service commissions.

No replies were received to letters addressed to the Railroad Commissions of Alabama, Arizona, Delaware and Maryland.

In California the Public Utilities Act, which became effective on March 23, 1912, gave the Railroad Commission jurisdiction over the service of railways in that state including block signals and safety device. No rulings, however, have as yet been issued by that Commission.

The Indiana Railroad Commission gives no reference to rulings which have been made by it since the compulsory law requiring block signals became effective January 1, 1912. This law was referred to in last year's report (page 198, 1911, Engineering Association Proceedings. The law of 1907 simply provided for an approved block system. In view of the court decision that the language was not definite enough to support an action, and in order that there might be no doubt, the Indiana Railroad Commission drafted an amendment to the Act of 1907. This bill passed and is now Chapter 188 of the Acts of 1911. The essential features of the present law are contained in the following paragraphs:

"'That after the first day of January, 1912, it shall be unlawful for any person, firm or corporation, or lessee or receiver of any person, firm or corporation, which shall own or operate any line of steam or interurban railroad in this state to operate any train or car over such railroad by steam, by electric power or other power, unless such railroad is equipped with and has in operation an automatic block system or other system approved by the Railroad Commission of Indiana for the control of train or car movements thereon, unless the time therefor be extended by such Railroad Commission.

"Full power and authority are also hereby conferred upon such Commission to permit, authorize and order in place of the automatic block, either a controlled manual block, or a manual block, or a dispatcher's block, or any other form of block or other signaling system that is or may be hereafter devised or used, if in the judgment of such Commission it shall be made to appear that a controlled manual block, or a manual block, or a dispatcher's block, or any other form of block or other signaling system now or hereafter devised or used shall reasonably conserve the safety of life and property, and whenever such order is made by the Railroad Commission, and such other form of block or other signaling system is installed, operated and maintained in obedience to such order, it shall be taken and held as a full compliance with this act."

Power is conferred upon the Commission to extend the time upon a showing of a reasonable necessity for such extension and also to relieve any such carrier if it shall be made to appear that the volume of traffic is such that trains can be dispatched without hazard to life or property. The penalty for violation is $1,000 per week. Under

the first act and the amendment there has been and will be a great deal of the mileage of the roads in the state equipped with adequate block systems. The compulsory law is pronounced successful. Not only has the block signal mileage increased, but the systems now in operation in the state are, in the opinion of the Commission, more efficient than they formerly were, and during the next two years the Commission expects to accomplish a great deal in the direction of efficient block signaling.

In Massachusetts, Minnesota, and New York the railway and public service commissions have authority to require the installation of block signals, but it does not appear that any general rulings on this subject have been made by these commissions, although installations of block signaling protection have been required in a few cases.

The Board of Railway Commissioners of Canada advise that the matter of block signals for electric railways in the Dominion has been referred to a committee which has not yet made a report.

SUMMARY OF THE DATA SHEETS AND BLOCK SIGNALS TO BE INSTALLED DURING 1912 BY ELECTRIC RAILWAYS

Only 50 companies out of the total membership of 365 in the Association replied to the Data Sheets sent out last year. In view of this,—and in order to get complete data as to the conditions of operation on electric railways, and such a number of opinions as would be of the most value to your Committee in making its recommendations,—it was considered advisable to repeat the questions of last year in the Data Sheet sent out this year. The summary of the replies to this Data Sheet is presented herewith in Appendix C.

The report of the 1911 Committee, referred to the mileage now equipped with block signaling on the railways of the United States as of January 1, 1911. During 1911 this was increased by 5,142 miles, making the total number of miles operated under the automatic block system on January 1, 1912, 20,335, the manual mileage 56,075, and the total length of road operated under the block system 76,410 miles. The increase in the automatic signaled mileage in 1911 was over 100 miles greater than the increase in manual block mileage.

The Report of the 1911 Committee also contained a short summary of the conditions governing electric railway signaling and its necessity under present conditions of rapid growth in traffic and the operation of heavy equipment at high speed. The fundamental differences between steam and electric road operation were also referred to at length.

With respect to two-position signaling on electric railroads your Committee considered it advisable to include in its report a short summary of present practice. The development of signaling on electric railways has been subject to the same influences that had so much to do with the growth of signaling on steam roads. Lack of recommended standards; widely diverse geographical conditions, and

local requirements of each situation; patents on signaling apparatus and systems; and various other less effective but equally important considerations have rather fostered than retarded the multiplicity of signal forms and appliances which characterize present day electric road signaling. Semaphore and disk signals are used for day indications, although lights—red for stop and green or white for proceed—are universally employed for night signals. The semaphores are operated in the upper and lower right-hand quardrants and the upper left-hand quadrant, and give indications in two and three positions in each of these quadrants. On some roads the signal blade is suspended from the center instead of the end. The stop indication is universally given with the semaphore arm horizontal, the proceed-with-caution indication is given sometimes with the arm at 45 deg. and sometimes with a forked end arm at 60 deg. from the horizontal. The proceed signal is given both by square-end and pointed-end blades in the vertical and 60-deg. position.

On account of the many designs and systems of signals now being installed (many of them in an experimental stage) and the great number of efforts being made to work out a satisfactory and inexpensive system of signals for electric railroads, it has not been considered advisable on the part of your Committee to make definite recommendations in answer to the queries contained in the report of the 1911 Committee on Block Signals.

CONCLUSIONS AND RECOMMENDATIONS

Your Committee recommends as "Standard" practice the following:

1. In all signaling the use of the three fundamental indications:
   - (*a*) Stop.
   - (*b*) Proceed-with-caution.
   - (*c*) Proceed.

2. *Where* semaphore signals *are used they shall be so arranged as to indicate* (indicating in) three positions, in the upper left-hand quadrant.*

* Italicised words indicate amendment at Convention

3. The following aspects in three-position signaling:

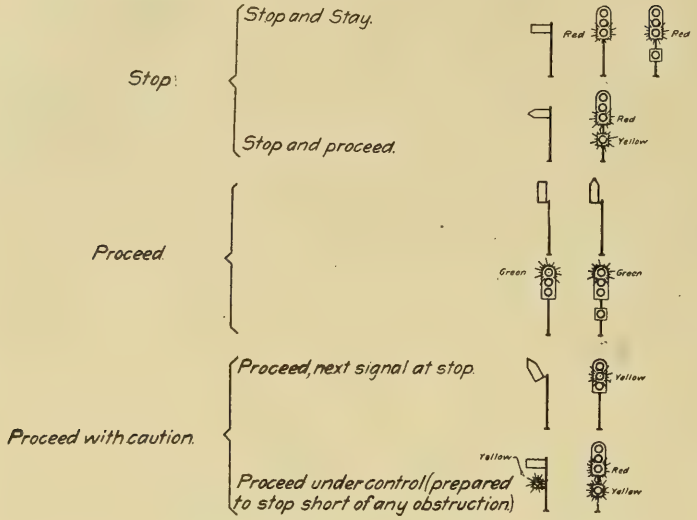


FIG. 1. SHOWING ASPECTS IN THREE-POSITION SIGNALING.

4. Your Committee recommends as good practice in two-position signaling the following aspects:

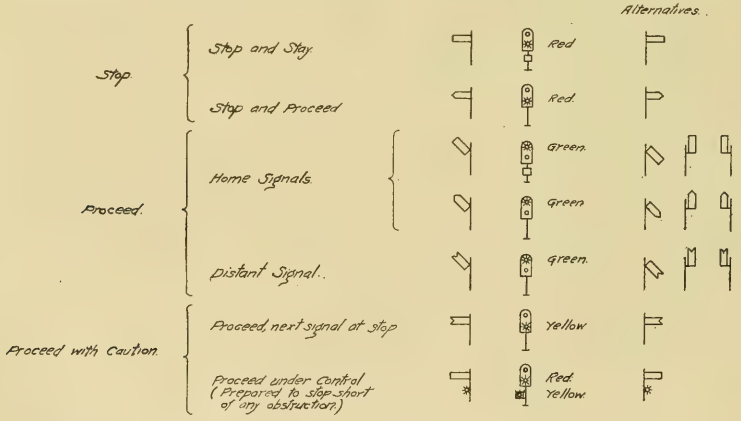


FIG. 2. SHOWING ASPECTS IN TWO-POSITION SIGNALING.

5. Your Committee recommends, for high-speed interurban service, that automatic signals be controlled by the use of continuous track circuits, and that expenditures be concentrated on continuous track circuit control with a cheaper form of indication in preference to a more expensive form of signal and a less reliable control.*

(5) 6. Your Committee recommends that the Committee for 1913 continue the study of the many systems of signaling now being installed, and, if possible, endeavor to answer the queries propounded by the 1911 Committee, modified, however, as follows:

First: Recommendations for signaling single-track suburban railways — headway between 5 and 30 minutes — speed not exceeding 20 miles per hour.

Second: Recommendations for signaling double-track suburban railway — headway between one and ten minutes — speed not exceeding 30 miles per hour.

Third: Recommendations for signaling single-track interurban railway — headway not less than one hour — speed 40 to 60 miles per hour.

Fourth: Recommendations for signaling single-track interurban railway — headway as frequent as 15 minutes with trains in several sections — speed 40 to 60 miles per hour.

Fifth: Recommendations for signaling double-track interurban railways — headways as frequent as five minutes — and speed 40 to 60 miles per hour.

Respectfully submitted,

J. M. Waldron, *Chairman,*
C. D. Emmons, *Vice-Chairman,*
C. F. Conn,
C. H. Morrison,
B. E. Merwin,
John Leisenring,

Joint Committee on Block Signals for Electric Railways.

* This recommendation referred back to Committee by Convention and ordered stricken from report.

APPENDIX A

SUMMARY OF INSTALLATIONS OF SIGNAL APPARATUS SUBSEQUENT TO THE 1911 REPORT

The report of the 1911 Committee on Block Signals was accompanied by:

Appendix A, Block Signal System.
" B, Fundamental Principal of Control Circuits.
" C, Descriptions of Typical Signaling Plans for Electric Railways.
" Ca, Curve Protection.
Cb, Train Dispatchers Control of Signals.
" D, Absolute Permissive Block System.
" E, Light Signals.
" F, Automatic Train Stops.
" G, Miscellaneous Signal Apparatus.
" H, Automatic Block Signals on the Illinois Traction System. (An abstract of an article by John Leisenring, Signal Engineer, appearing in the *Electric Railway Journal* for June 24, 1911.) Automatic Block Signals and Train Stops on the Interurban Line of the Washington Water Power Co., appearing in the *Electric Railway Journal,* for Dec. 17, 1910.
" I, Kinsman Block System.
" K, Nachod Signal System.
" L, Dispatchers Signal System.

This comprehensive descriptive matter presented in general the fundamental principles on which practically all of the signal systems depend for their operation and also illustrated the chief features of the designs of apparatus on the market. Accordingly, your Committee will undertake only to set forth brief descriptions of new or improved apparatus that have been developed since the preparation of the previous report, together with some statements by the manufacturers regarding installations.

Installation by The Union Switch and Signal Co.

This company has furnished material for the installation of 52 miles of block signal protection with continuous track circuits on interurban roads during the six months ending July 1, 1912. This territory is divided into 55 blocks, protected by 80 semaphore signals and 46 light signals.

These figures include certain portions of the signaling on the Rochester, Syracuse & Eastern and the Illinois Traction Systems, but do not include 32.7 miles previously installed on the Rochester, Syracuse & Eastern and 80 miles installed on the Illinois Traction System, prior to the year 1912. The above figures are also exclusive of the signaling on the New York, Westchester & Boston Railway and other heavy suburban electric traction roads. The signals have been installed on seven different railroads in the States of New York, Pennsylvania, Maryland, Indiana, Illinois, North Carolina and California — four of these have been initial installations and three extensions of present signal systems.

This signaling provides, in single track work, for each car to be fully protected in the rear as well as head-on, *i. e.,* but one car is allowed in a block at any one time. All installations employ alternating current, this being used for low voltage track circuits and for 110 volt semaphore and light signals.

No propulsion other than the regular signaling current is employed for signaling purposes. The current for the signaling system is distributed by means of separate mains which may also supply station and switch lighting. This makes the signaling independent of interruptions and low voltage conditions, which would be incidental to its supply by the propulsion or lighting systems.

All of this signaling is controlled by continuous track circuits only, which insures the signals remaining in the danger position as long as the block which they govern is occupied. Each switch which is not trailed through is equipped with circuit controllers so arranged as to hold to "danger" all signals governing the block in which the switch is located when the points are not correctly set for the main line.

All of this signaling has been installed with the "double rail" track circuits, which provide a two-rail return for the car propulsion current.

The list includes what is, up to the present time, the largest installation of high grade light signals for automatic track circuit block signaling purposes on any interurban road and also an installation that has been made in a remarkably short length of time.

All of these installations, with one exception, are on roads having 600 or 1,200 volt direct current propulsion, the exception being that on the Chicago, Lake Shore & South Bend Railroad, where 6600 volts a. c. is employed.

Power for each of these installations is taken from auxiliary apparatus consisting of transformers and switchboards located in substations whereby available a. c. energy is transformed to 2200 volts and distributed over the signal territory. Connected to this 2200 volt line are transformers provided with secondaries giving 10 volts for the track and 110 volts for operating the signals and lights.

The line wire equipment for these installations requires two 2200

volt and three or four 110 volt line wires, extending the length of the signaled territory. The former are generally carried on a separate two-pin cross arm, but in some cases all are carried on one cross arm. Transformers, high tension plug cutouts and lightning arresters are mounted on additional short arms located on the regular trolley or on stub poles.

All of the semaphore signals installed by this Company to date on interurban roads are operated by the Style-B mechanism, of which there are over 55,000 in service on steam and electric railroads. All of the semaphores on interurban roads are of the two-position type, and mostly operate in the upper left-hand quadrant. The others operate in the lower left-hand quadrant or as center-suspended blades.

The light signals which this company has installed on interurban roads are of two sizes, one having 5 in. the other 8 in. lenses, but are otherwise similar for they are constructed of cast iron and are provided with hoods and background shields. The home signals have one red and one green lens, whereas the distant signals are provided with one yellow and one green lens, Each lens has behind it two lamp bulbs wired in multiple as it is assumed that only one lamp will burn out at a time and hoods are provided over the lenses to offset the effect of the sun. No reflectors are employed. On four installations of light signals the electric arc headlights located just above the floor level of cars are found to have no effect on the distinctness of the indication.

The lamps employed in these signals are of the Tungsten type and the energy required for one entire signal is less than that required for one 16 c. p. carbon lamp.

To provide an indication for movements onto the main track from switches at special locations, switch indicators, or miniature unlighted signals are provided, having small semaphores and are mounted in iron cases on iron posts about four feet in height.

Diagrams of several of the installations (Figs. 3, 4, 5 and 6) are presented as interesting studies in the location of the signals and signal controlling limits, the latter shown by lines leading from the signal to the end of the territory controlling the same.

The foregoing is a general statement concerning all these installations and the following, a more detailed description of each:

ROCHESTER, SYRACUSE & EASTERN RAILROAD

(Baldwinsville to Fulton, N. Y.)

This signaling, the fourth installation of The Union Switch and Signal Company's apparatus on this railroad, presents no novelty over prior installations on this system.

The additional, or new, protection extends over 10.7 miles of track divided into three blocks, each block being provided with a preliminary and two normal clear semaphore signals.

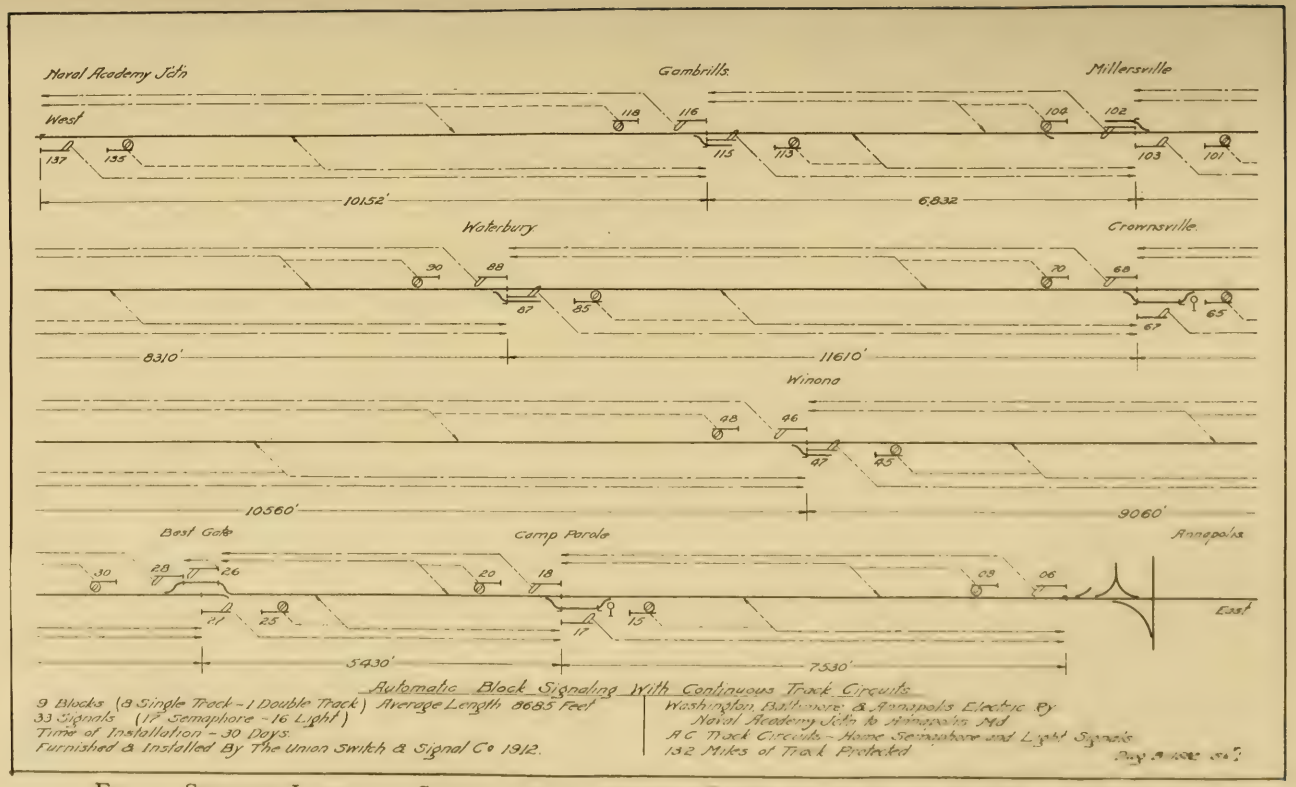


FIG. 3. SHOWING LAYOUT OF SIGNALS ON WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY.

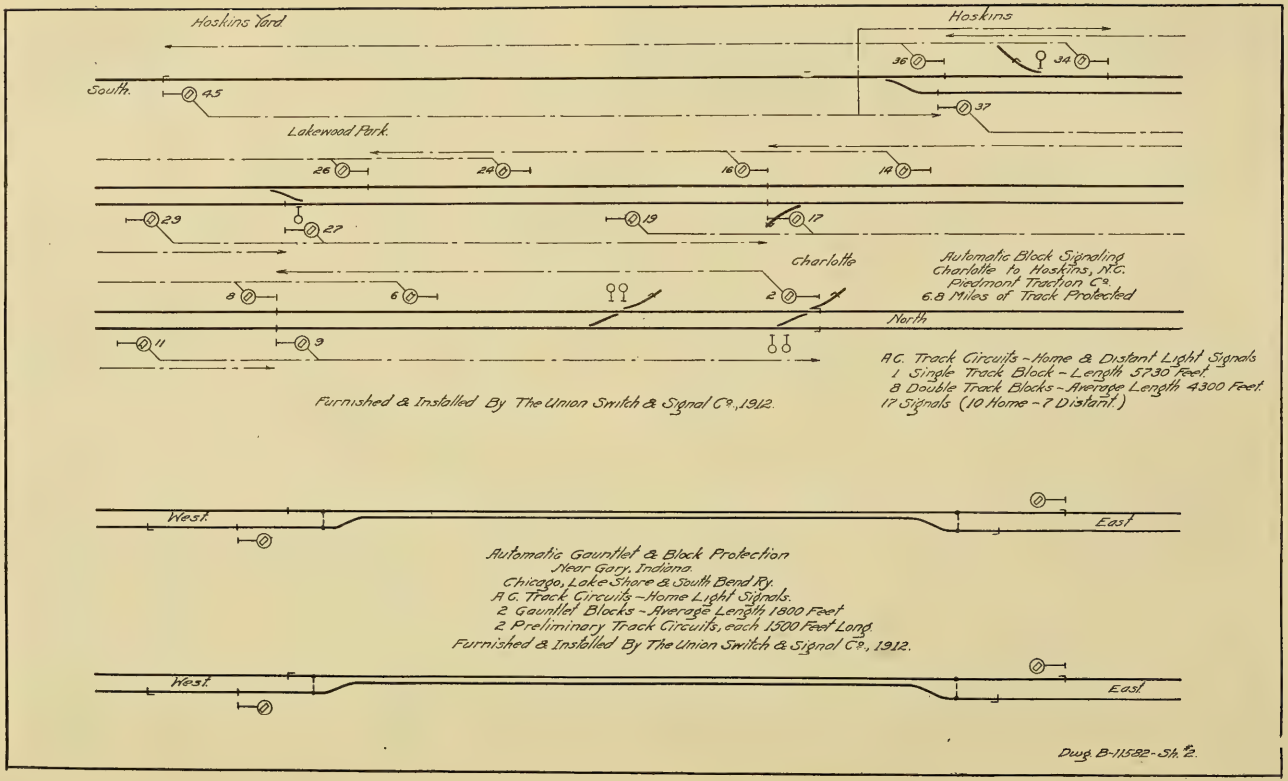


FIG. 4. SHOWING LAYOUT OF SIGNALS ON CHICAGO, LAKE SHORE & SOUTH BEND RAILWAY.

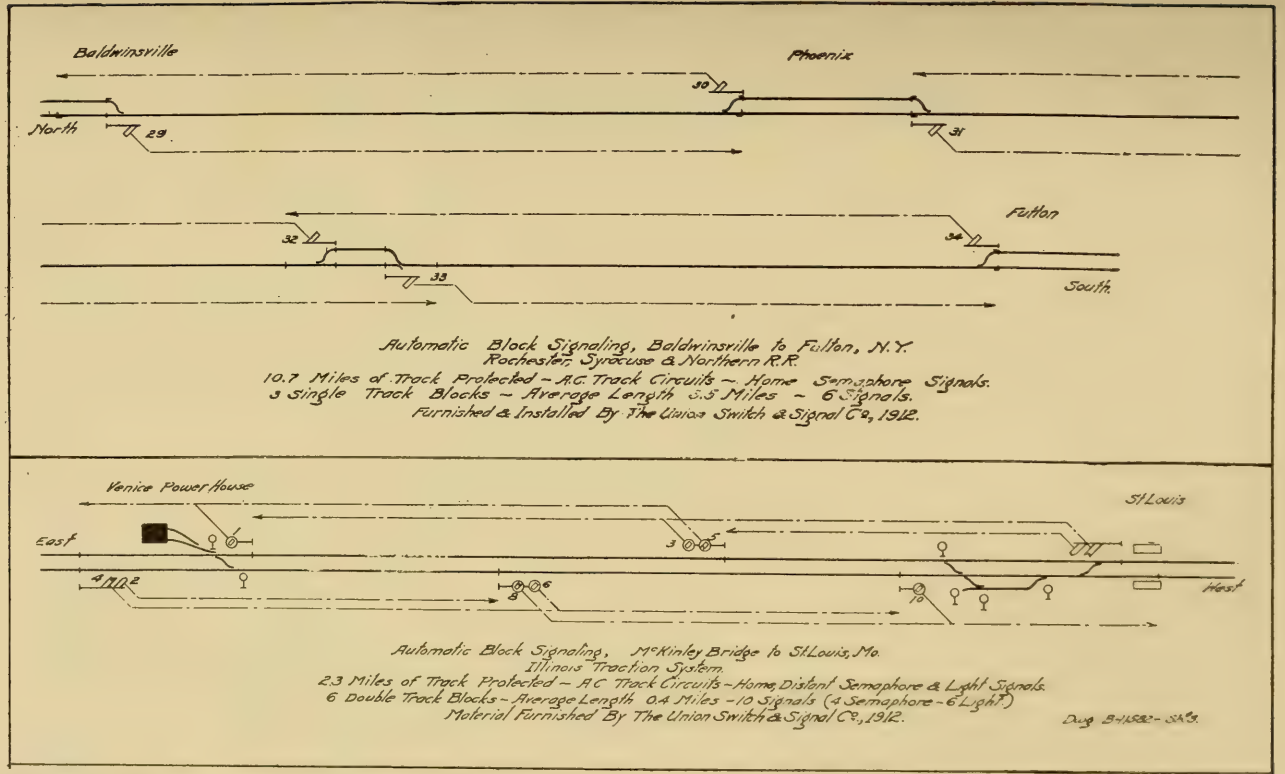


FIG. 5. SHOWING LAYOUT OF SIGNALS ON ROCHESTER, SYRACUSE & EASTERN RAILROAD AND ON ILLINOIS TRACTION SYSTEM.

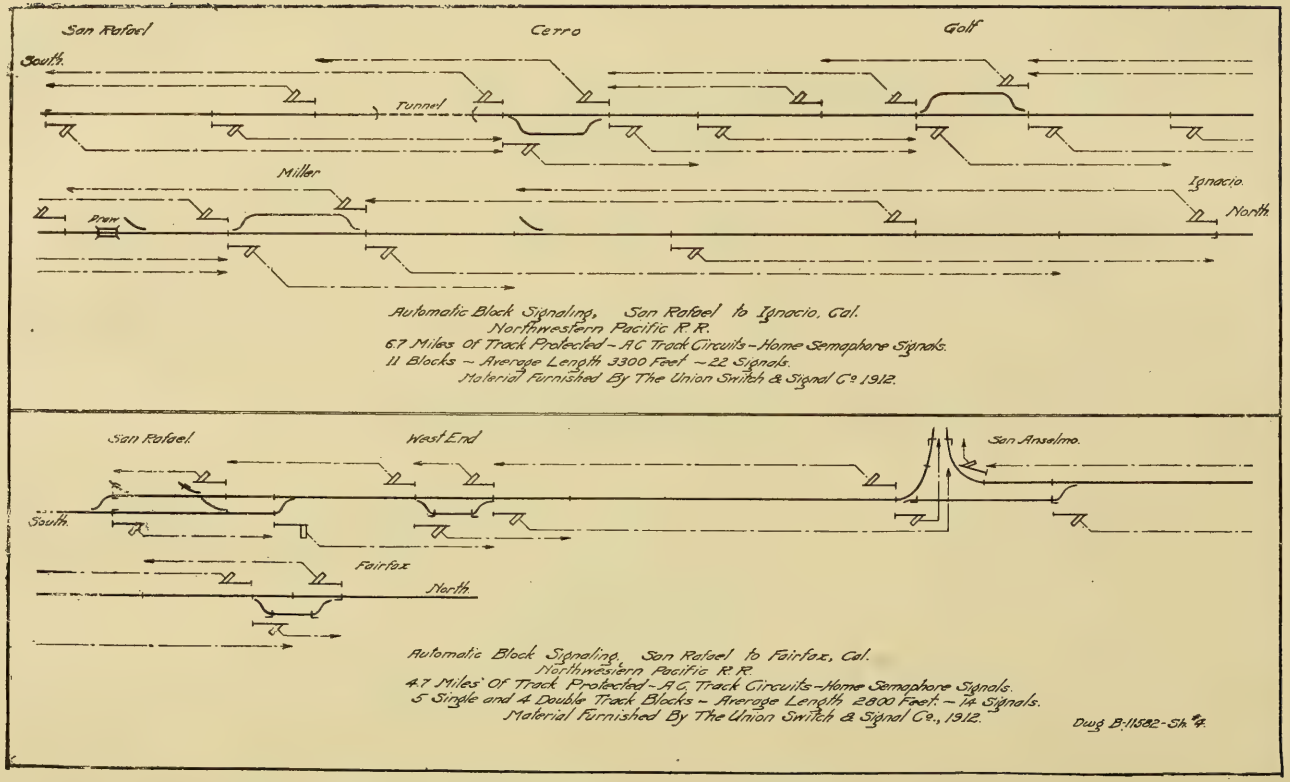

San Rafael
Cerro
Golf
South.
Tunnel
Miller
Ignacio.
North.
Automatic Block Signaling, San Rafael to Ignacio, Cal.
Northwestern Pacific R. R.
6.7 Miles Of Track Protected - AC Track Circuits - Home Semaphore Signals.
11 Blocks - Average Length 3300 Feet - 22 Signals.
Material Furnished By The Union Switch & Signal Co. 1912.
San Rafael
West End
San Anselmo.
South.
Fairfax
North.
Automatic Block Signaling, San Rafael to Fairfax, Cal.
Northwestern Pacific R. R.
4.7 Miles Of Track Protected - AC Track Circuits - Home Semaphore Signals.
5 Single and 4 Double Track Blocks - Average Length 2800 Feet. - 14 Signals.
Material Furnished By The Union Switch & Signal Co., 1912.
Dwg B-11582-Sh 4.

FIG. 6. SHOWING LAYOUTS OF SIGNALS ON NORTHWESTERN PACIFIC RAILROAD.

The installation shown in Fig. 5 is divided into two sections by a short stretch of double track at Phoenix and the longer section is in turn divided into two blocks by a passing siding about midway of the distance. This siding and the main track between its fouling points includes one track circuit, controlling only Signals 31 and 34.

The signals are the Union Style-B type with center suspended blades, and the balance of the apparatus is practically the same as that described in the 1911 report relating the Illinois Traction System.

PIEDMONT TRACTION COMPANY

(Charlotte to Hoskins, N. C.)

This installation has ten home and seven distant light signals protecting 6.8 miles of line, most of which is double track. Reference has already been made to this installation on account of the number of light signals controlled by continuous track circuit blocking. Distant signals are provided for the majority of the home signals, these distants being used as repeaters controlled directly by the home signal in advance. Switch indicators are provided at various points to further protect and expedite traffic. The traffic over this signaled territory is city, interurban and freight, with a large pleasure business between Charlotte and Lakewood Park.

The layout of the signals with the controlling limits of each is shown in Fig. 4, and comprises nine blocks, eight of which are on the double track and one on the single track. The signals are of the 8 in. lens type, while the balance of the apparatus is similar to that described in the 1911 report relating to the Illinois Traction System signaling.

CHICAGO, LAKE SHORE & SOUTH BEND RAILWAY

(Near Gary, Indiana.)

This installation consists of two gauntlet track protections, each having two signals protecting the traffic passing over viaducts where the view is obscured by grades as well as curves. Each of these blocks is about 1,800 ft. long and on one end of each a preliminary is provided which permits but one car accepting a clear signal at any one time. The track circuits are arranged so that the signals will clear up as soon as a car leaves the fouling point of the gauntlet.

The signals employed in this installation are of the same type as described under the "Piedmont Traction Company" and the track arrangement is shown in Fig. 4.

WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY COMPANY

(Naval Academy Junction to Annapolis, Md.)

The Washington, Baltimore and Annapolis Electric Railway connects the three cities named in its title, by a first class, high speed electric

line, having double track between Baltimore and Washington and single track from a point called Annapolis Junction, where it connects with the Baltimore and Ohio Railroad, to Annapolis.

This single track line is 20 miles in length, and the eastern division, or that portion from Naval Academy Junction to Annapolis, which is a distance of 13.2 miles, was signaled in the thirty days preceding the Democratic Convention of this year — thus establishing a record for quick installation of a complete system of automatic protection.

The traffic over this road is passenger, local freight and through freight. Trains of more than one car are used for passenger traffic as conditions demand. A shuttle or city service is also maintained between Annapolis and Camp Parole.

On special occasions regular steam trains of the Baltimore & Ohio Railroad and the Pennsylvania Railroad convey a large number of passengers to the Naval Academy exercises at Annapolis over this line. This section was built as a steam road about 1836 and retains the many original curves, almost all of which, being in cuts, allow only a short view of the roadway.

The layout of tracks and signals with signal controlling limits is shown in Fig. 3.

There are four stub and three double ended sidings on this line, one of which, "Best Gate," is a regular meeting point for scheduled cars. At this siding the switches are set for all cars to take the right hand track and trail through the exit switch. At other double-ended sidings cars proceed at speed on the main line if they have no meets. Whenever possible these double-ended sidings are used for meets with long freight trains.

All schemes for single track automatic signals, prior to this installation, employed a preliminary at one or both ends of the block in order to prevent two opposing cars from simultaneously entering a block under clear signals. This, under normal conditions, operates perfectly, but with a deranged schedule may cause either further delay to a car already late or require signal apparatus at the entrance to a preliminary to prevent such delay.

A further study of preliminaries and their effects can be secured by a reference to the 1911 report of this Committee, but it cannot be denied that their elimination is desirable if the substitute does not introduce unsafe or undesirable features. With a view to overcoming the objection to preliminaries, The Union Switch & Signal Company, by the substitution of two additional signals, eliminated them. These signals are of the 5 in. lens light type. This scheme of signaling with semaphore signals at the ends of the blocks was adopted by Washington, Baltimore and Annapolis Electric Railway Co. As the scheme is entirely new and is the first installation of such an arrangement, it will be described somewhat in detail. Each signal is numbered according to the miles, and nearest tenth, from Annapolis.

Eastbound signal numbers end in an odd tenth because eastbound trains are odd-numbered whereas westbound signal numbers end in an even tenth for the same reason.

The blocks extend from siding to siding and each has four signals,

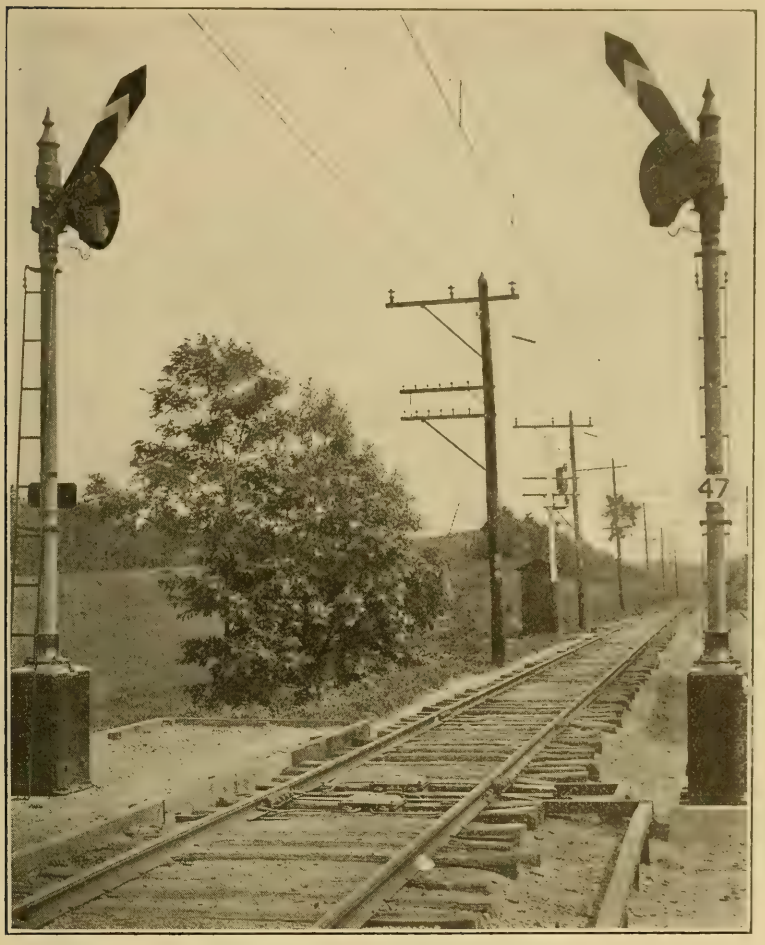


FIG. 7. SHOWING SEMAPHORE SIGNALS ON WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY.

two semaphores, one at each end of the block, and two light signals, each about 1000 ft. or more in advance of the semaphore signals. Referring to Fig. 3, the block between Gambrills and Millersville has

semaphore Signals 115 and 102, with light Signals 113 and 104 respectively, in advance of the semaphores.

The one track section for this block has its transformer, or source

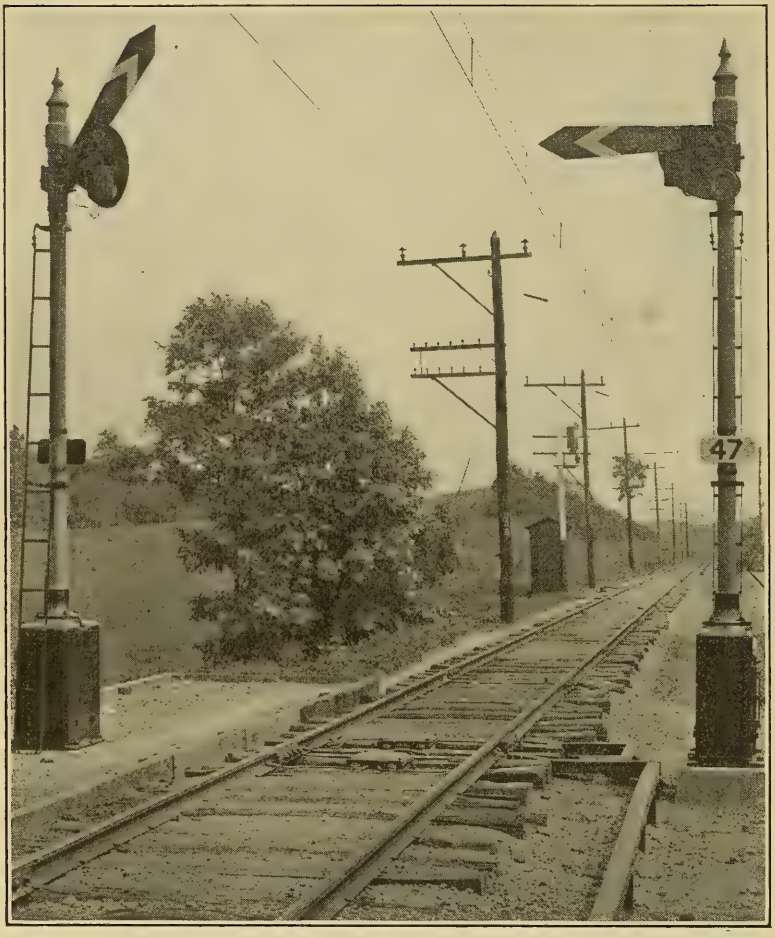


Fig. 8. Showing Semaphore Signals on Washington, Baltimore & Annapolis Electric Railway.

of energy, in the center and operates two track relays. One of these relays, located at Signal 115, is controlled by the track to a point about 1000 ft. or more *east* of the center of the block, and the other,

located at Signal 102, is controlled from this signal to a point about 1000 ft. *west* of the center.

Each semaphore signal is controlled by *both* track relays or the entire block. Each light signal is controlled by one track relay only, i. e., the one at the opposite end of the block and, therefore, by the two-thirds of the block at that end.

FIG. 9. SHOWING SWITCH INDICATOR, SWITCH CIRCUIT CONTROLLER AND SWITCH ROD INSULATIONS ON WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY.

Under this operation, an east-bound car entering the block under clear Signal 115 places this signal, as well as Signal 102 and 104 at Millersville to danger. As it passes Signal 113 at clear and reaches the arrow point just *east* of this signal, it places the latter at danger.

When the car is in the center of the block, between the two arrow points, all four signals are held at danger.

The car is protected, head and rear, until Signal 102 is passed, when the block may again be entered at either end. In this operation west-bound Signal 104 will clear when the car passes the arrow point just west of this signal, but this is immaterial as Signal 102 is still providing head-on protection. Similarly, Signal 113 is clear when the car is between this signal and the arrow point just east of the same, but the car is protected in the rear by Signal 115.

The great advantage of this scheme is the facility with which car meets can be made, as opposing cars can proceed to a meeting point, such as Gambrills, without delaying each other or being subject to special rules as in systems having preliminaries. This is true because *each block is a unit* and a car in one block does not affect the movements of a car approaching an *adjoining* block.

The light signals act as a check should two approaching cars pass opposing semaphore signals at the same time: for example, should an east-bound car pass Signal 115 at the same time that a west-bound car passes Signal 102, both would be stopped by Signals 113 and 104 respectively, and one must back out of the block so that the other may proceed.

Another advantage is the allowable close headway for following cars due to the elimination of the preliminary, which is secured without complication of apparatus. Under a preliminary system, following cars in one direction are spaced the block distance plus the preliminary, which in such a case becomes an overlap, and as there may be passenger stops in a preliminary the delay to a following car may be extended.

This scheme is also flexible as regards special conditions, two of which are shown in this signaling. One is the addition of switch indicators at Crownsville and Camp Parole, the sidings being about 1000 feet long and located on curves. Each indicator is controlled by the block in which the switch is located and a preliminary extending beyond the west end of the block. This preliminary is installed, for example, at Camp Parole to prevent the switch being opened to let a car out of the siding while an east-bound car is approaching Signal 17, and, therefore, the latter car, on the main line, will have the right to enter the block.

By the use of Signal 15 no preliminary is required for this indicator at the east end of the block, for should a west-bound car pass Signal 06 as the switch is thrown, the car in the siding would be stopped by the west-bound car having placed Signal 15 to danger.

The other special situation is the regular meeting point and passenger stop at Best Gate Siding. Here it will be noted that Signals 18 and 27 are controlled by the track section between Signals 18, 26 and 27, and Signals 47 and 28 by the sections between Signals 47, 28 and

27, whereas the track section on the siding controls Signal 26 only. If a *west-bound* car reaches the siding first and runs past Signal 26, Signal 27 is clear for an east-bound car, and when the latter passes Signal 27 the west-bound car may proceed promptly under Signal 28. Should the *east-bound* car arrive first it will be held at Signal 27 until the west-bound car passes Signal 26. The passenger stop is located at Signal 27 and the east-bound car discharges passengers *east* of the signal, if the westbound car is ready to proceed, but if the westbound car has not arrived the passengers are discharged *west* of the signal.

Signal 26 was provided to allow a west-bound car to pass Signal 18 and still protect a car standing on the Best Gate siding.

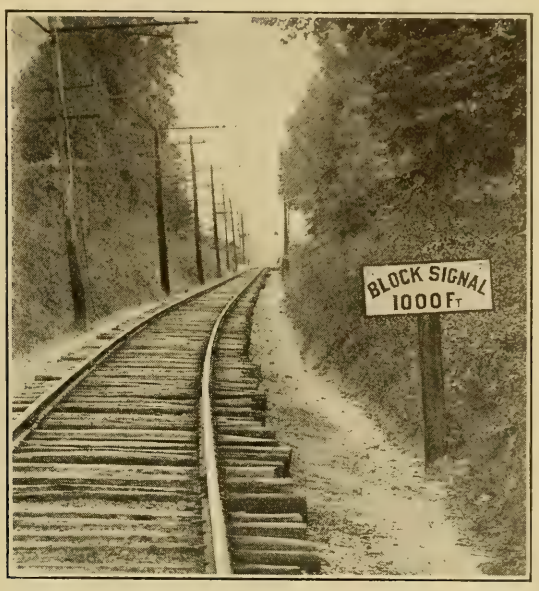


FIG. 10. SHOWING DISTANT MARKER BOARD ON WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY.

The previously mentioned shuttle service between Annapolis and Camp Parole is protected by Signals 06 and 17 as the car does not proceed west of Signal 17 and is, therefore, protected by the two signals mentioned. This signal displaced a hand operated light signal arrangement between Camp Parole and Annapolis.

The signals at the sidings are located at the fouling point instead of at the switch point, in order to better protect movements into the sidings and also cause minimum delay to cars approaching the switch.

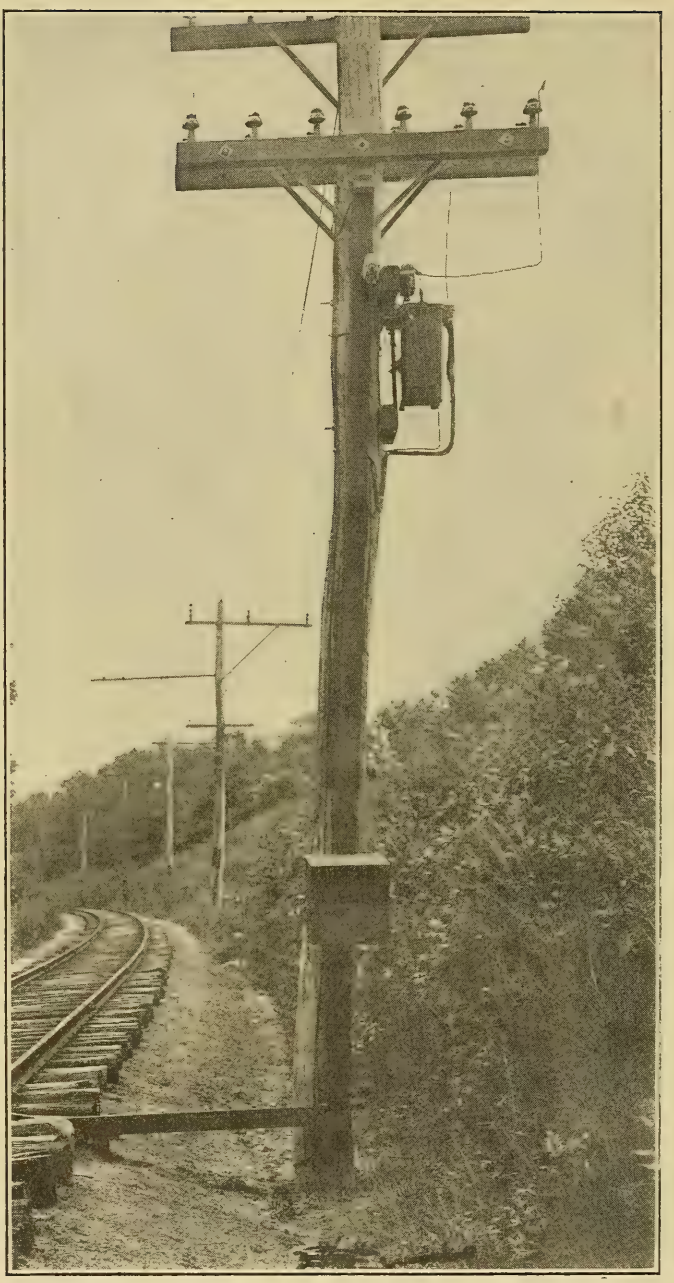


FIG. 11. SHOWING TRANSFORMER LOCATION ON WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY.

For example:— Movements in or out of the switch at Gambrills do not effect the signals of the Cambrills-Millersville block, and also do not prevent a west-bound car proceeding safely to Signal 116, which will be at danger if the switch is open or if a car is fouling the main track. This switch will, of course, control Signals 137 and 135 as well as 116. If the signals were located at the switch point, an eastbound car taking the siding would necessarily hold Signal 102 at danger.

On this road cars head-in and back-out of sidings except when prevented by special conditions.

At present there are no distant signals but marker boards stating "Block Signal 1000 Feet" are used instead.

Power for this installation is taken from a substation located at Naval Academy Junction where available 370 volts, 25 cycle current is transformed to 2200 volts for distribution over the signaled territory. A separate one panel switchboard with ammeter and switches is included in the substation equipment. Transformers are located in the center of each block and tapped to the 2200 volt line, supply current through one secondary at 10 volts for the track circuits and through another secondary at 110 volts for the signal circuits. Each light is controlled directly by a 110 volt vane type relay which in turn is controlled by the galvanometer type track relays.

The light signals are of the 5 in. lens type previously mentioned, one lens being green with its lamp controlled by the front contact of the line relay and the other lens of red having its

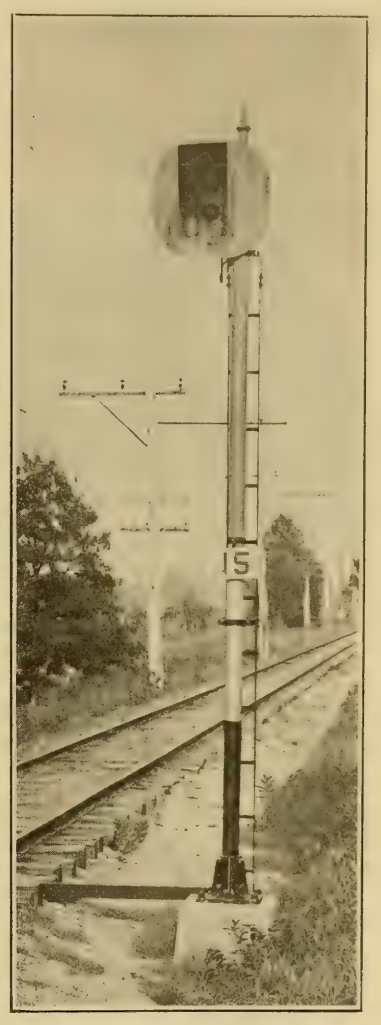


FIG. 12. SHOWING LIGHT SIGNAL WITH 5 IN. LENSES ON WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY.

lamps controlled by the back contract of the same relay. The semaphore signals are controlled directly by contacts on the track relays and also by contacts on the light signal line relay, without the use of extra line relays.

The semaphore signals are electrically lighted, two position 0 to 60 deg., upper left-hand quadrant, Style-B, bottom post mechanism, as described in the 1911 report relating to the Illinois Traction System signaling.

Adjoining track circuits are separated by impedance bonds having a capacity of 500 amperes per rail and all insulated rail joints are of the Keystone type. The track circuits are carried into the sidings to

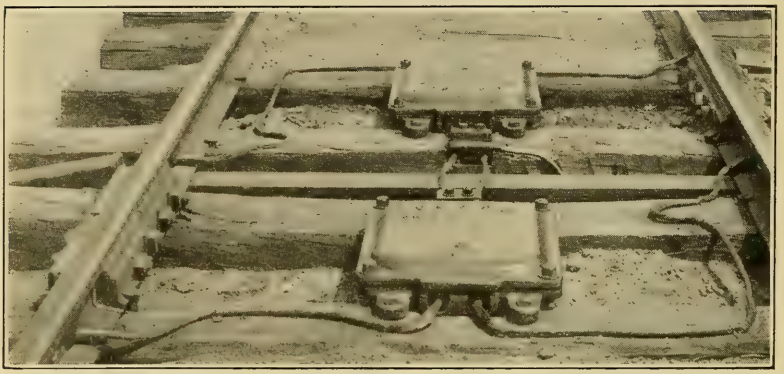


FIG. 13. SHOWING IMPEDANCE BONDS ON WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILWAY.

the fouling or clearance points of same. Circuit controllers are placed on all switches except at Best Gate Siding where cars trail through the points. All circuits are fused and provided with lightning arresters connected to a deep ground. An existing ground wire protecting the propulsion feed and high tension wires is grounded to the rails by connection to the neutral of the impedance bonds located at each siding. The relays and low tension lightning arresters are located in wooden boxes mounted on the trolley poles or on separate iron posts.

Figs. 7 to 14 inclusive represent signals and other signal apparatus as installed on this road.

SCRANTON AND BINGHAMTON TRACTION CO.

One block, .08 miles long, with four signals, was installed on this road to protect very bad curves and grades, the signaling scheme and apparatus being the same as that installed on the Washington, Baltimore & Annapolis Electric Railway previously described, and is not, therefore, diagramed or further explained.

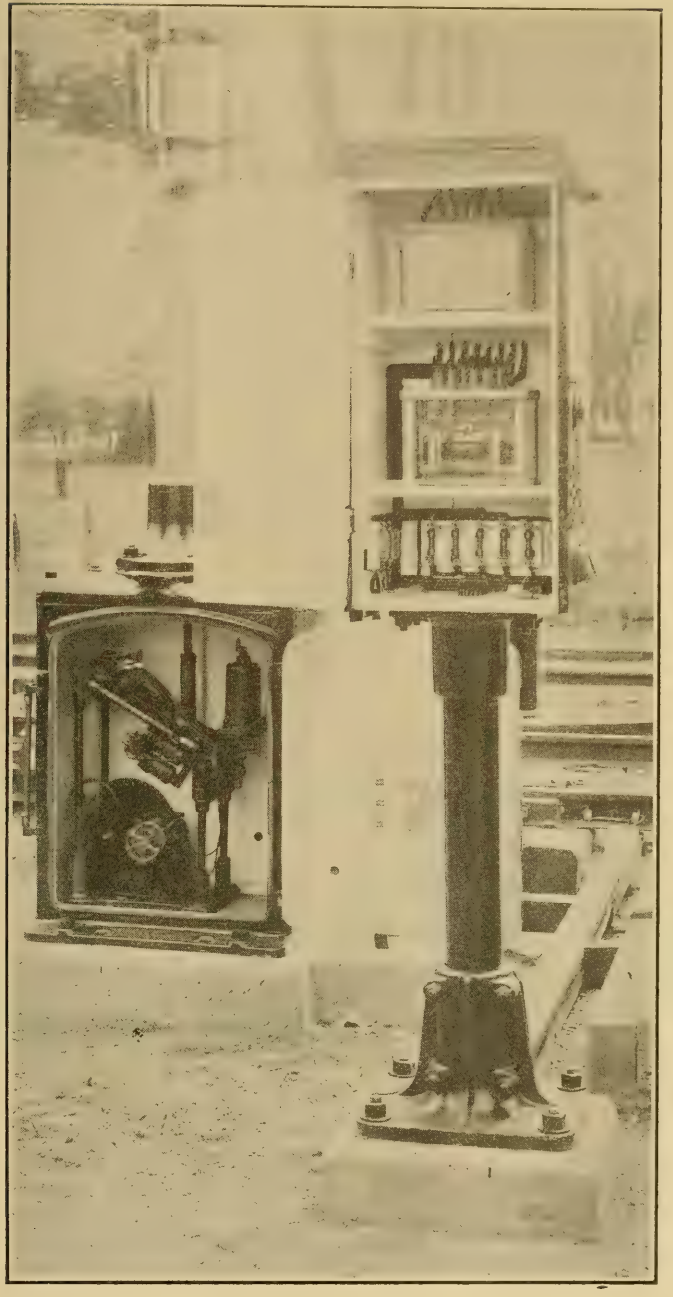


FIG. 14. SHOWING TRAIN RELAYS, RELAY SHELTER AND SEMAPHORE OPERATING MECHANISM ON WASHINGTON, BALTIMORE AND ANNAPOLIS ELECTRIC RAILWAY.

NORTHWESTERN PACIFIC RAILROAD

(San Rafael to Ignacio, Cal. and San Rafael to Fairfax, Cal.)

These two installations protect 11.4 miles of track with 36 semaphore signals, the territory being divided into 16 single-track and 4 double-track blocks. The traffic is passenger and freight trains and a portion of the line is a combination of narrow and standard gauge with one common running rail.

This signaling is an extension of the installation made on the North Shore R. R. in 1903, by the Union Switch & Signal Co., which was the first a. c. track circuit system ever installed.

The signals are two-position, 0 to 60 deg., lower right-hand quadrant, operated by Style-B bottom post mechanism. Fig. 6 shows a general layout of the signaling with the controlling limits of each signal.

ILLINOIS TRACTION SYSTEM

(McKinley Bridge, St. Louis, Mo.)

The Illinois Traction System has erected across the Mississippi River at St. Louis what is probably the largest bridge for electric traction service in the world. A signal system is now being installed to protect 2.3 miles of track with two home signals and four home and distant signals. The bridge is double tracked to handle the heavy city and interurban business and three blocks are provided for each track, this blocking covering the bridge proper and its approaches, a distance of 1.2 miles.

At the entrance to each signaled track is located a two-arm home and distant semaphore signal, each arm the Illinois Traction System standard, two-position, 0 to 60 deg., operating in the upper left-hand quadrant. The home arm governs the first block and the distant is the repeater of the next block in advance. The next or second block on each track is a home and distant, each signal being of the 8-in. lens type. This was adopted because of the physical impossibility of securing a view of a two-arm semaphore within the clearance between cars and overhead bridge girders.

At the entrance to the third or last block, a single home light signal of the same type is installed, which governs to the end of the signaled track. The arrangement of the signaling is the same for both tracks.

The signaling was installed not only to protect following movements but to protect switches located on the east approach leading into the Venice power house and on the west approach leading into industries and a large freight yard.

To protect traffic due to these switches. switch indicators have been installed at all switches. Another special feature is the installation of a warning bell at a dangerous wagon road crossing, this bell being controlled by the signaling track circuits.

In addition to this McKinley bridge signaling, the Illinois Traction System has installed this year previous to July 1, six miles of track circuit block signaling divided into five blocks and employing 16 semaphore signals, ten of which are home signals and six are distant signals.

These installations are similar in every respect to those installed by this company on 80 miles of track during the year 1911.

Installations by the General Railway Signal Company

Oregon Electric Railway

(Portland to Garden Home.)

On June 29, 1912, this company placed in service on the above named railway between the points mentioned, an a. c. automatic block signal system covering approximately 6.5 miles of single track and including a number of stub end and passing sidings. Twenty-two three-position upper quadrant semaphore signals are employed operating in the left-hand quadrant. The control of the signals is absolute, intermediates being used to permit following moves closer than the distance between passing points. At all passing sidings, four signals are employed. The semaphores are operated by Model 2-A direct connected mechanisms equipped with series type commutating motors as shown in Fig. 15.

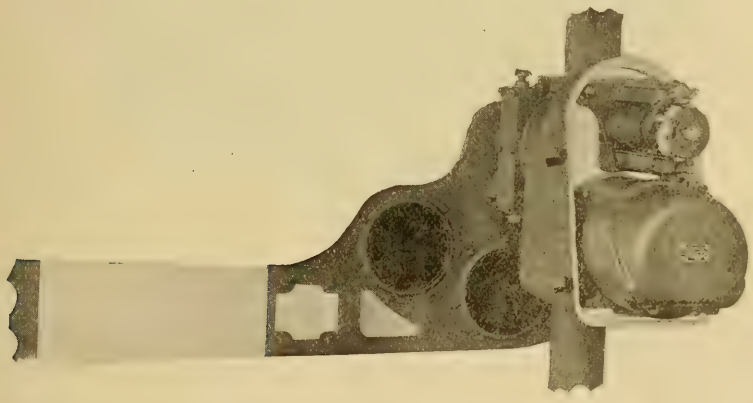


Fig. 15 — 2-A Signal Mechanism.

The control of the signals is by means of a polarized line through the medium of three-position relays. Continuous track circuits for the control of all signals are employed, both rails being retained for the return of the propulsion current. The track relays are the General Railway Signal Company's Model-2, Form-A Universal type,

similar to that shown in Fig. 16. The three-position line relays above mentioned are also of this same type. The arrangement of the signals is shown in Fig. 17, page 31.

AURORA, ELGIN & CHICAGO RAILROAD

(Bellwood Avenue.)

This company has installed on the Aurora, Elgin & Chicago R. R. two three-position upper quadrant signals operating in the upper left hand quadrant, arranged to govern a crossover from one track to the other.

The installation includes several switch indicators, switch circuit controllers, etc., in order to make the protection complete. Reactance

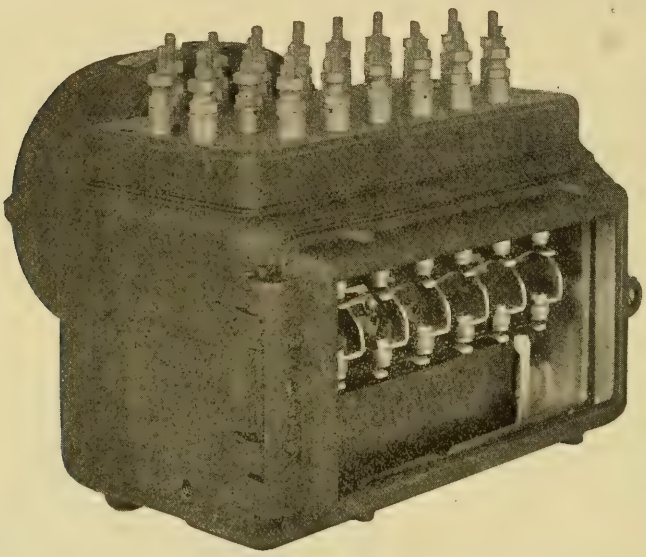


FIG. 16 — UNIVERSAL POLYPHASE RELAY.

bonds are used to provide a double rail return for the propulsion current, the control of the signals being by means of the continuous track circuit.

The track relays are our Model-2 Form-A Universal type above described. The signal mechanisms are of the General Railway Signal Company's Model 2-A direct connected type, equipped with single phase commutating type series motors operated directly over the line without the intervention of line relays. The signals are the same as those shown above in Fig. 15.

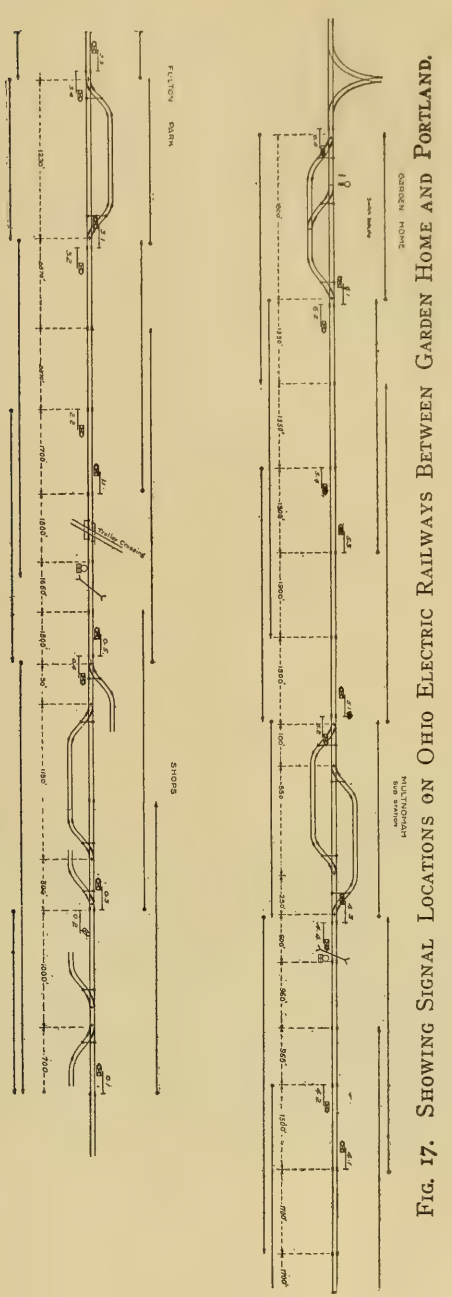


FIG. 17. SHOWING SIGNAL LOCATIONS ON OHIO ELECTRIC RAILWAYS BETWEEN GARDEN HOME AND PORTLAND.

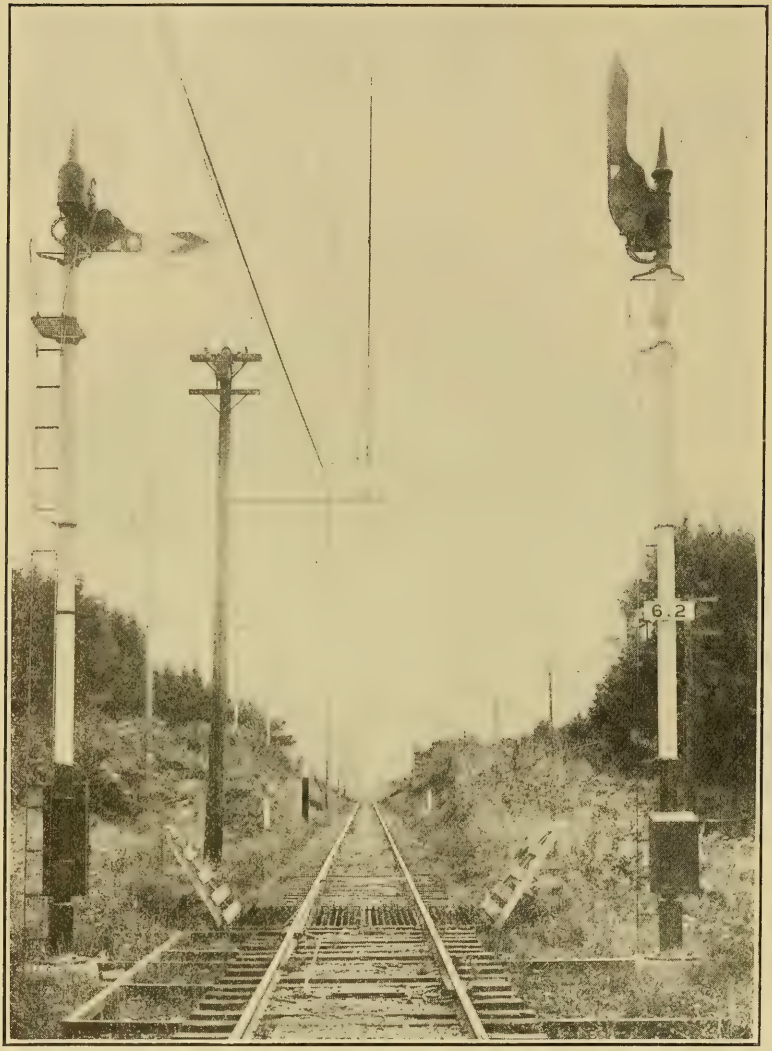


FIG. 18. MODEL 2-A SIGNALS ON OREGON ELECTRIC RAILROAD.

FIG. 19. SHOWING MODEL 2-A SIGNALS ON OREGON ELECTRIC RAILROAD.

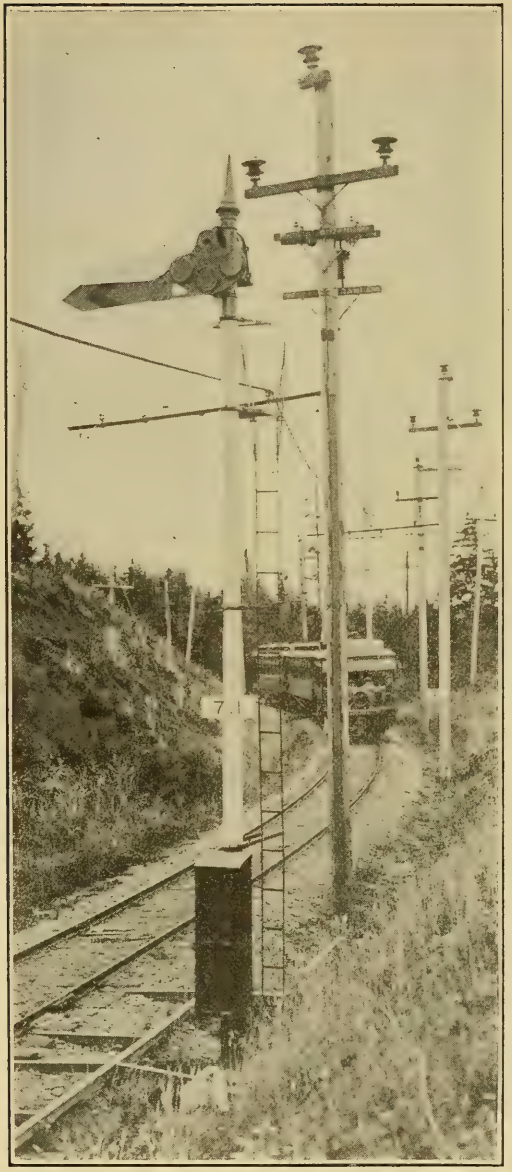


FIG. 20. MODEL 2-A SIGNALS ON OREGON ELECTRIC RAILWAY.

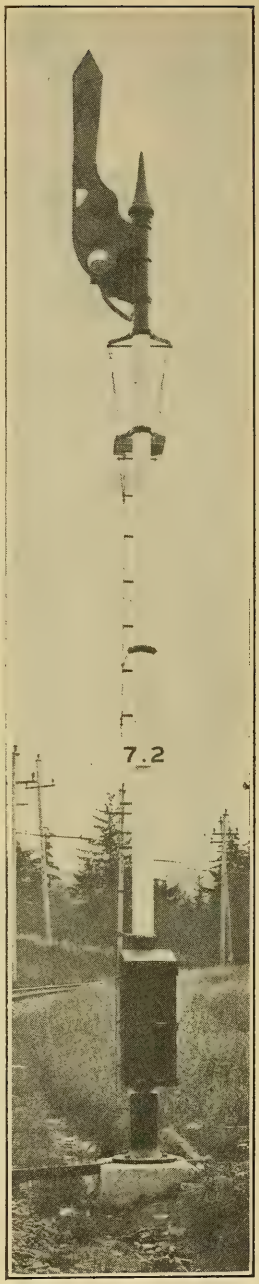


FIG. 21. SHOWING MODEL 2-A SIGNALS ON OREGON ELECTRIC RAILROAD.

FT. DODGE, DES MOINES & SOUTHERN RAILWAY

(Boone to Ft. Dodge.)

This company has installed on the above named railway 22 light signals governing about 18 miles of single track including eight blocks. At three of the passing points four signals are used — two inbound and two outbound. The signals are absolute. A unique feature in connection with this installation is the use of but one line wire for the control of opposing signals, the return being over the rails. Line relays immune to the effects of direct current are employed to avoid interference with such direct current as may be shunted over the line from the rails. Both the line and track relays are our Model-2 Form-A Universal type as shown above in Fig. 16. The control of the signals is by means of the continuous track circuit, both rails being retained for the propulsion current return.

Reactance bonds are of the type shown in Fig. 22. These bonds are the same as those which we have formerly been supplying except that

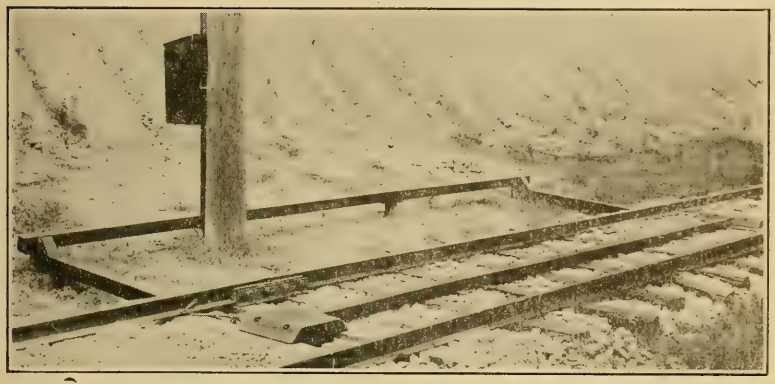


FIG. 22. SHOWING REACTANCE BONDS ON FT. DODGE, DES MOINES & SOUTHERN RAILROAD.

the covers are arranged with sloping sides to prevent dragging parts from catching and are provided with a receptacle into which trunking, for the common connection between the bonds, can enter. The leads are brought out to the sides in a convenient manner for connection to the rails.

UNION TRACTION COMPANY OF INDIANA

(Anderson Division, Siding 13 to 22 inclusive.)

On the lines of this company an a. c. automatic block signal system covering approximately 18 miles of single track, including 9 blocks, 18 home and 6 distant signals has been installed. The General Railway Signal Company's absolute permissive block signal system is

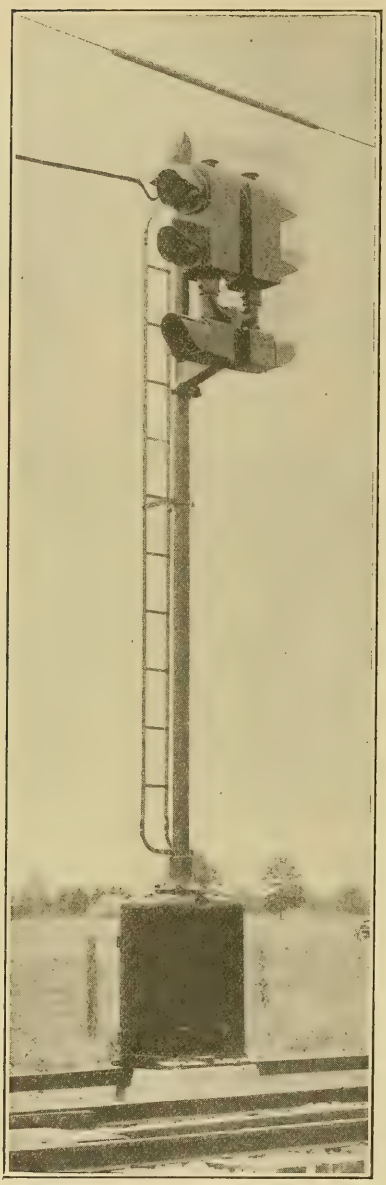


FIG. 23. SHOWING DOUBLE LIGHT SIGNAL WITH PERMISSIVE ATTACHMENTS INSTALLED IN PLACE.

employed providing absolute blacking for opposing movements but allowing one train to follow another into the same block under a permissive signal.

The general construction and arrangement of the signals is as shown in Fig. 23. The two upper lights constitute the main signal, the lower

FIG. 24. SHOWING RELAY HOUSING AT BASE OF SIGNAL MAST WITH RELAYS IN PLACE, TERMINAL BOARD, FUSES, ETC.

of the three lights being the permissive signal. A sheet iron relay housing is installed at the base as shown in Fig. 24, in which is located all the relays, fuses and other apparatus required at a location. Reactance bonds as shown in Fig. 22, and as described above in connection with the Ft. Dodge system, were employed. All track and

line relays are of the General Railway Signal Company's Model-2 Form-A Universal type as shown in Fig. 16.

A unique feature of the system consists in the use of but two line wires for the control of opposing signals, both the absolute and permissive indications being given over these same two wires, the circuit being so designed that the permissive indication having been given, neither of the proceed signals into said piece of single track can be

Fig. 25. Block Indicator in Place.

given until the permissive light has been extinguished. All of the sidings are double ended, the signals being located on the same mast at the center point of the sidings. In view of this arrangement it will of course be impossible for a man at the switch to see both of the signals. For this and other reasons indicators are employed at the switches to serve as repeaters for the signals which cannot be seen and

also to indicate the condition of the block governed by the normal danger signal. In certain cases, time element attachments are used in connection with the indicators to prevent a movement from the siding simultaneously with a train entering the block at the other end. All indicators are normally clear provided the block is unoccupied. The time element indicators are interconnected with the system in such manner that when a switch has been thrown they will go to stop and not clear until after a predetermined time has elapsed, provided the block has not been entered by a train in the meantime. The time element indicator, therefore, serves practically the same purpose as a preliminary track circuit, doing so at a greatly reduced cost. Distant signals are employed wherever a clear view of the home signal cannot be obtained a sufficient distance away to avoid slowing down. All distant signals are controlled by track circuits which will cause them to assume the stop position with a train between the distant and home signal.

The control of the signals is by means of the continuous track circuit, both rails being retained for the return of the propulsion current throughout the entire signaled territory.

Block indicators as shown by Fig. 25 are used at the commencement of all preliminaries to prevent a train approaching the meeting point interfering with an opposing train which may be late. The control is such that the indicator is lighted if the opposing block is occupied, thereby indicating to the motorman that he may proceed to the siding without interfering with the opposing train.

TERRE HAUTE, INDIANAPOLIS & EASTERN TRACTION CO.

(Duffs to Junction. Brazil and Terre Haute Division.)

This company has installed on the above named railroad between the points named and a. c. automatic block signal system governing approximately 15 miles of single track including six blocks and twelve signals. Fig. 26 shows a switch indicator with back cover removed, showing time element attachment, indicator movements, etc., as well as switch box and mechanical connection between switch indicator and switch points. Fig. 27 shows the front view of this same switch indicator, enclosed.

Fig. 28 shows a complete installation at a stub-end siding, with switch box, switch indicator, reactance bonds, signal pole, etc.

The arrangement and control of the signals and other details is the same as that employed in connection with the Union Traction Company of Indiana system described above. The only essential difference between the two systems being the use of stub end sidings on the lines of this company.

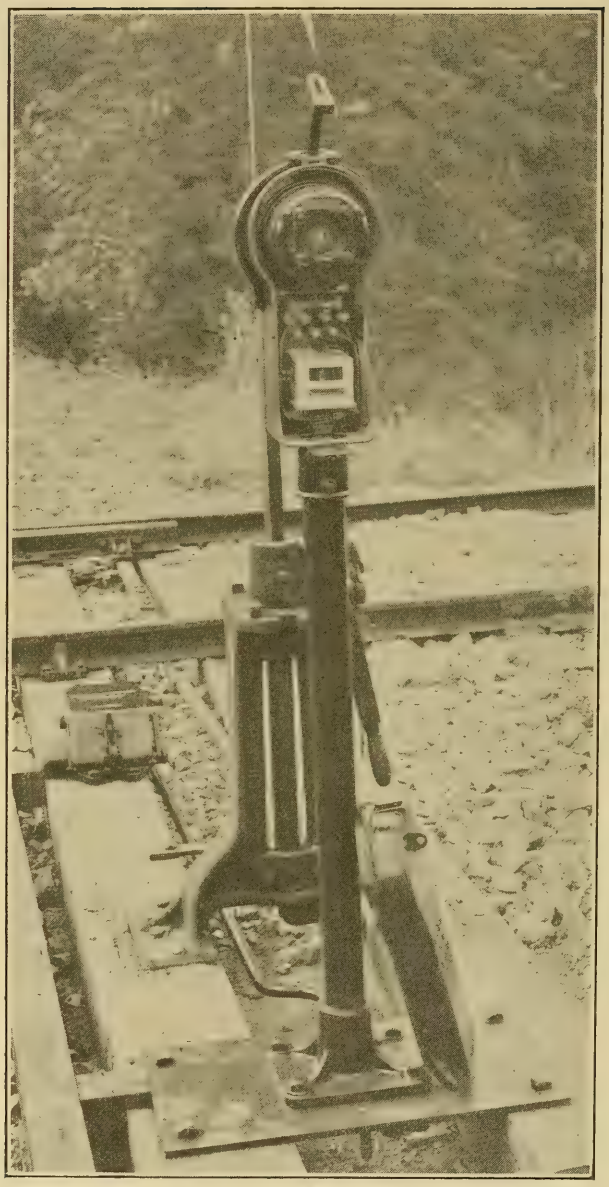


FIG. 26. SHOWING SWITCH INDICATOR WITH BACK COVER REMOVED.

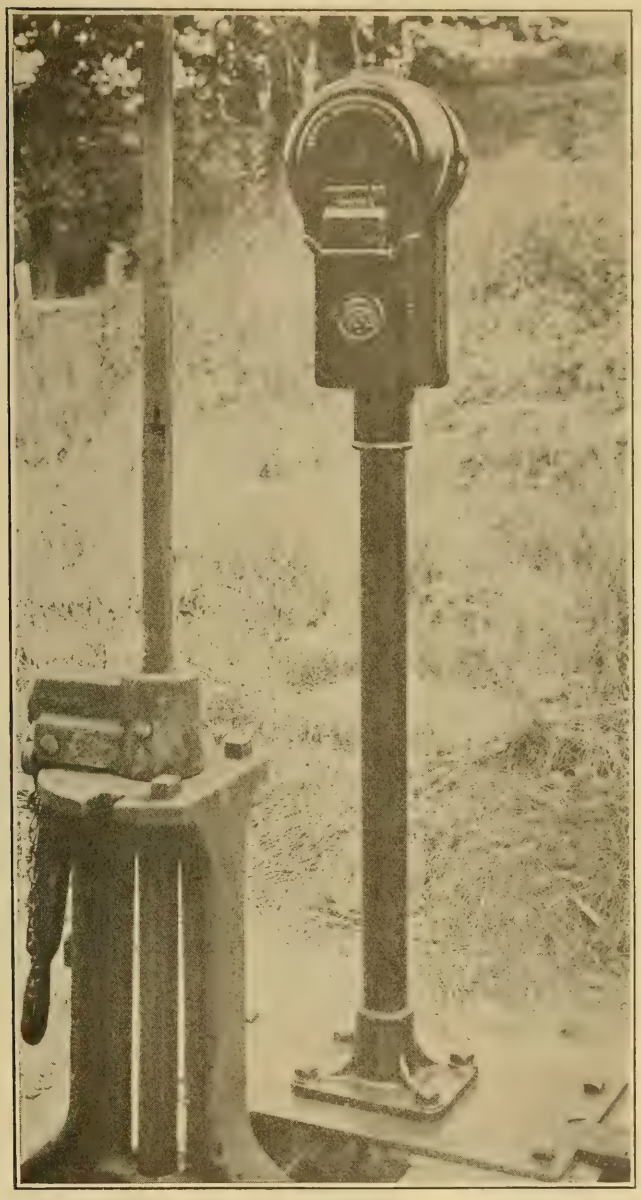


FIG. 27. SHOWING SWITCH INDICATOR ON TERRE HAUTE, INDIANAPOLIS & EASTERN TRACTION CO.

LEHIGH VALLEY TRANSIT COMPANY

(Emaus Junction to Norristown.)

This company is installing on the above named railroad an a. c. automatic block signal system covering approximately 41 miles of single track including 38 signals and 18 blocks. Twelve of the passing points will be stub end sidings and six will be passing sidings. Semaphore signals operating in two positions 0 to 90 deg. in the upper left-hand quadrant will be employed. Model 2-A direct connected mechanisms equipped with 25 cycle single phase induction motors will

FIG. 28. SHOWING SIGNAL INSTALLATION COMPLETE AT STREET END SIDING.

be used for operation of the semaphores. The signal masts will be mounted on housings similar to that shown in connection with the light signal, Fig. 23. All the relays and other apparatus required at a location will be mounted in these housings.

Absolute signaling will be employed. All track relays will be of the G. R. S. Co.'s Model-2 Form-A Universal type (Fig. 16) and all line relays will be of the Model-2 Form-B as shown in Fig. 29. Reactance

bonds of the type shown in Fig. 22 will be employed. The control of the signals will be by means of the continuous track circuit, both rails being retained for the return of the propulsion current. Switch indicators will be required at outlying points. In some cases indicators will be used at the sidings equipped with time element devices for the same purpose and as described in connection with the Union Traction Company of Indiana system above mentioned.

Fig. 29. Model-2 Form-B Line Relay.

PHILADELPHIA & WESTERN RAILWAY

(Villa Nova to Norristown.)

This company has installed on the Philadelphia and Western Railway between the points above mentioned an a. c. automatic block signal system governing six miles of double track and including seven blocks

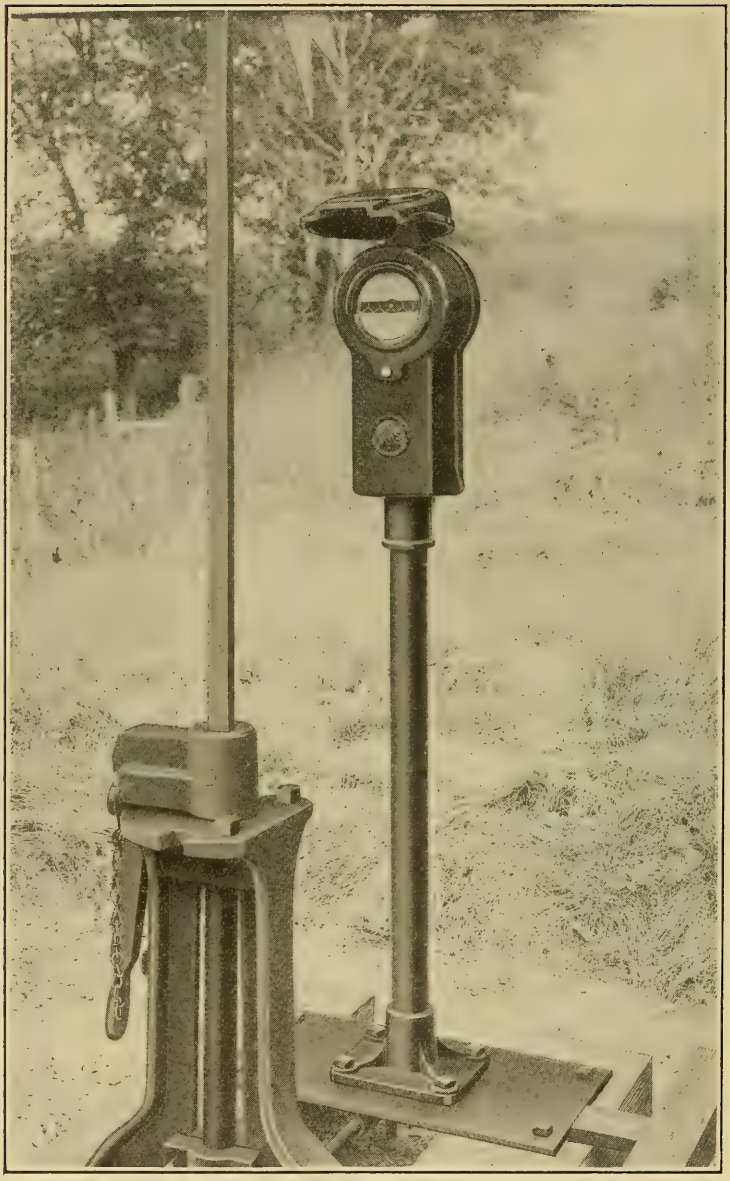


FIG. 30. SWITCH INDICATOR WITH FRONT COVER LIFTED UP, EXPOSING BLADE AND PUSH BUTTON.

with as many signals. The semaphores will operate, for the time being, 0 to 90 deg. in the upper quadrant. They are, however, so arranged that later on they can be operated in three positions. General Railway Signal Company's Model 2-A direct connected signal mechanisms will be employed for the operation of the semaphores and are equipped with 25 cycle single phase induction motors. The General Railway Signal Company's Universal type Model-2 Form-A relays, Fig. 16 will be employed. The line relays will be of the General Railway Signal Company's Model-2 Form-B as shown in Fig. 29. Reactance bonds of the type shown in Fig. 22, will be employed. At Villa Nova an interlocking plant will be installed for the control of the junction signals and switches at that point, the signal mechanisms, relays, etc., being the same as those used in connection with the block work. The control of the switches and signals will be by means of a mechanical interlocking machine, all signal levers being equipped with A. C. operated electric locks as a means of indicating when the signals have assumed the stop position. The signals will be controlled by a track circuit as in the case of the automatic signals.

NEW APPARATUS

Certain detail improvements in apparatus have been made as follows:

Reactance Bonds: In order to provide a bond which would make a better appearance in the roadway and also prevent the catching of any parts dragging from the rolling stock and at the same time permit of connections being made to the rails in a simple and direct manner, we have designed the arrangement shown in Fig. 22, which has been heretofore described in connection with the various systems installed by us. Another feature of this bond is that the leads between bonds and between the bonds and rails are concealed as far as possible. Aside from the external arrangement, the coils, core, etc., remain the same as before.

Relays: We have completed our line of Model-2 Form-B relays, one of which is shown in Fig. 29. These relays are essentially for use as line devices but they may also be used as track relays. They are considerably smaller than the Model-2 Form-A and therefore take up less room in the relay boxes. Their operating features are identical with the Model-2 Form-A, that is, a non-magnetic rotor is employed which makes the relay immune to direct current and responds only to alternating current. It is made in two sizes, four and six way respectively, the smaller size accommodating a maximum of four front and two back contacts, the larger size accommodating a maximum of six front and two back contacts. The relay can be made to operate in either two or three positions and when desired may be equipped with a blade and covered with an enameled sheet iron case, thus producing an indicator.

Indicators: Our a. c. indicator remains as before, with the exception that we have designed a time interval device which mounts in the indicator as shown by Fig. 26. We have also provided a cast iron cover as shown by Fig. 27, which drops over the face of the indicator

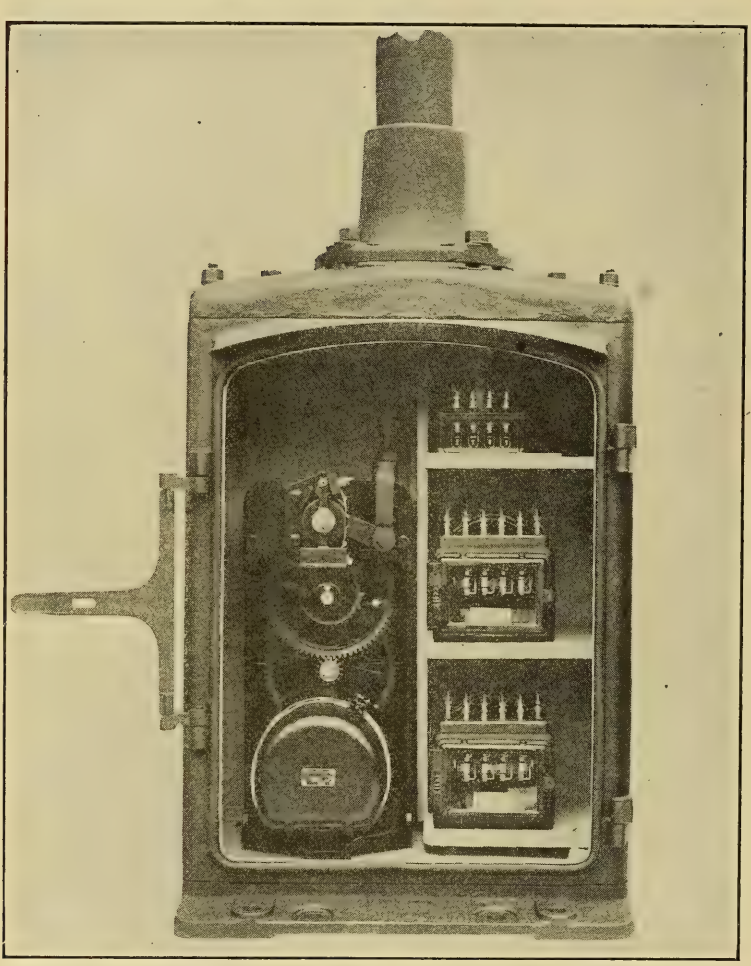


FIG. 31. SHOWING MODEL 2-A SIGNAL BASE OF MAST MECHANISM.

and which may be lifted by the trainman as shown in Fig. 30, whenever the indicator is to be observed. It is the expectation that this cover will prevent the breaking of the glass by stones being thrown and will also keep sleet and snow from preventing the blade being seen. A

push button or key switch attachment can be added to the indicator as required. The movement may be either of the rotating non-magnetic shell type immune to the effects of direct current or of the Z-armature type, the latter being somewhat less expensive and consuming less energy. In short the indicator described and illustrated above is universal, performing all of the functions required in connection with switch indicators.

Signals: Our Universal Model 2-A Signal remains unchanged in principle. We have, however, in the past year perfected the induction motor for use in connection with this signal and are supplying a number of them in connection with recent installations. We also wish to call attention to our Base of Pole Model 2-A Signal Mechanism as shown by Fig. 31. This mechanism was exhibited at Atlantic City last

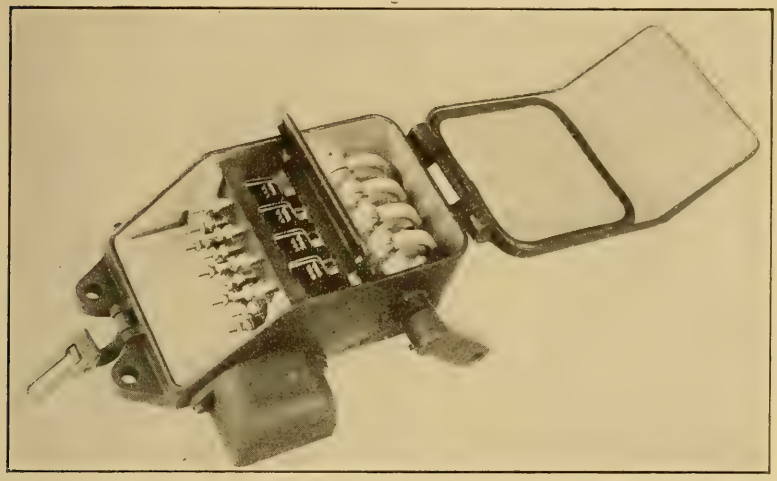


FIG. 32. SHOWING SWITCH CIRCUIT CONTROLLER.

year and it will be noted that there is room in the mechanism case for at least three relays, it being possible to add the fourth by placing the shaft above the mechanism, which can be equipped either with the commutating type or induction motor as desired.

Switch Circuit Controllers, etc.: We exhibited at Atlantic City last year our latest improved switch circuit controller as shown in Fig. 32. The features of this controller are described in our bulletin No. 123, page 23. During the past year we have made various minor improvements which have resulted in a universal box fully meeting the exacting requirements of railway business.

Block Indicators: We have developed a device which has been termed a block indicator as shown by Fig. 25 for use as described in connec-

tion with the Union Traction Company of Indiana signal system. This device provides a very simple means of indicating to the motorman whether or not an opposing block is occupied, thus preventing him from interfering with the movements of an opposing train which may be late.

Installations by the Nachod Signal Company

This company has furnished your Committee with the following list of signals installed during the past year.

Name of Road	Nachod signals in use		Remarks
	Quantity	Type	
Altoona & Logan Valley Electric Ry. Co.	2	M	
Bridgeton & Millville Trac. Co.	2	M	
Camaguey Electric Co. (Cuba)	4	CD	
Chattanooga Ry. and Light Co.	26	C	First few of these included in 1911 report.
Chicago & Milwaukee Elec. R. R. Co.	2	C	55 miles per hour operation reported on this road.
Christchurch Tramway Board, New Zealand.	2	CD	
East St. Louis & Suburban Ry. Co.	2	CD	
Fonda, Johnstown & Gloversville R. R.	3	HD	Double track signals.
Fort Smith Light & Traction Co.	2	C	
Cie. Gen. Francaise de Tramways, Reseau de Havre.	2	C	
Hudson Valley Railway Co.	2	C	
Illinois Traction Co.	56	CD	First set of these included in 1911 report.
Knoxville Railway & Light Co.	4 1 repeater signal.	CD	
Lehigh Valley Transit Co.	22 6	CD MD	Four of these signals were on trial at the time of your 1911 report.
Lewistown & Reedsville Elec. Ry. Co.	2	CD	
Little Rock Railway & Elec. Co.	14	C	
Louisville Railway Co.	2	CD	
Mahoning & Shenango Ry. & Lt. Co.	34	C	This company has been using some of these signals since 1909. A set at Stop 12 operated 37,000 times to date for six months with no failures, no maintenance.
Nashville Interurban Railway	2	C	Protect locomotive, passenger and express traffic.
New Jersey & Pennsylvania Trac. Co.	14	MD	
New York State Railways	6	C	
Philadelphia Rapid Transit Co.	1 contactor operating U. S. & S. Co. semaphore; 5 contactors operating U. S. & S. signals for subway surface cars.		Eureka breaker mentioned in 1911 report has been replaced Dec. 1911 with Nachod non-directional contactor.
Parkersburg, Marietta & Interurban Ry. Co.	20	MD	
Roanoke Ry. & Elec. Co.	19	M	
Scranton Railway Co.	17	M	
Sheffield Co. (The)	2	C	
Southwest Missouri R. R. Co.	3	HD	Double track curve protection.

INSTALLATIONS BY THE NACHOD SIGNAL COMPANY—(*Continued*).

NAME OF ROAD	Nachod signals in use		REMARKS
	Quantity	Type	
Spokane & Inland Empire R. R. Co....	2	C	
Springfield (Mo.) Traction Co.....	2	CD	
St. Joseph & Savannah Interurban Ry..	18	CD	Interurban, single end sidings.
Tri-State Railway & Elec. Co.....	8	CD	Two of these signals included in report of Ohio Valley Elec. Co. for 1911.
Valley Traction Co.....	2	CD	This company conducting very careful test since Nov. 1911.
Virginia Ry. and Power Co.....	8 trolley contactors.		Used in connection with card schedule record.
Wheeling Traction Co.....	38	C	Referring to page 15 of your 1911 report, regarding the Wheeling Trac. Co. the test mentioned resulted in the equipping of their lines with 38 Nachod signals.
Wilkes-Barre Railway Co.....	22	MD	

DESCRIPTION OF THE NACHOD SIGNAL FOR ELECTRIC RAILWAYS

In the design of signals operated by intermittent contact devices, proper attention has not always been directed to the manner of failure of the signals. The system herewith described will not only permit of flexible car operation, but, in the event of disarrangements of the circuits or apparatus, will also indicate stop signals, or at least not permit proceed signals to be given. With the mechanical contactor it is believed that no clear failure* can be produced by any of the following conditions:

(1) The breaking of any line wire;
(2) the crossing of any line wires;
(3) the grounding of any line wires;
(4) the open circuiting of any operating coil;
(5) the short circuiting of any operating coil;
(6) the sticking of any armature.

The disk type signal reinforced with brilliant light indications has been used instead of the more expensive semaphore. The indications are enclosed in a weather-proof case, and are therefore protected from adverse weather effects and corrosion of bearings, etc., due to moisture. On account of this, the excessive torque which must be otherwise provided for an occasional accumulation of snow and ice is not required in this type. Fig. 33 shows the signal mounted on a universal bracket. The indications are visible 800 to 1,200 ft. in ordinary weather.

*This excepts failures at the contactor which are arranged to be plainly visible to the motorman by placing the contactor 200 or 300 feet in advance of the signal.

The Nachod automatic signal, known as Type MD and described herewith, is a disk type signal actuated by the power in the trolley line and controlled by trolley contact devices. Four line wires are required. For opposing movements on single track the signals are normally neutral; but when a stop signal has been set at the far end by a car leaving a siding to enter the block, a permissive signal will be shown to the car as evidence of that fact. The permissive signal is interlocked with the stop signal so that it cannot be displayed unless the latter is showing. Fig. 35 shows the line wiring diagram for a set of signals.

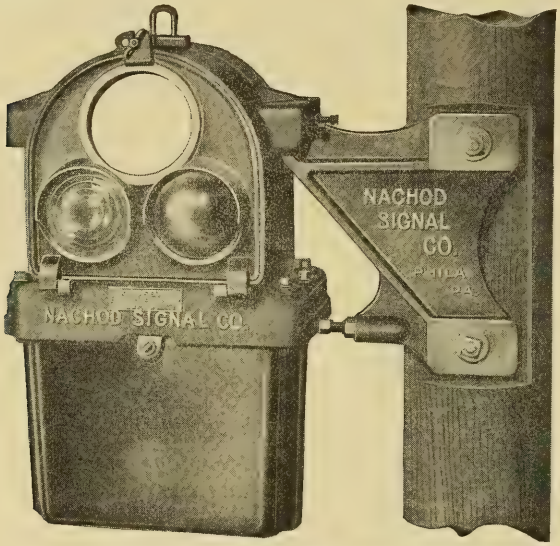


Fig. 33. Signal Box on Brackett, Permissive Indication.

The operation of the system is briefly as follows: A car or train entering under the left-hand contactor will change the signal from neutral or normal, no lights and no disks — the condition of indication with no car on the block limits as defined by the contactors — to a permissive signal, a white disk and a white light. This is an indication that the stop signal, a red light and a red disk, is showing at the right-hand end of the block. When the car passes under the contactor at the right, both signals will be restored to normal. Should, however, a second car follow into the block, the motorman will see not a neutral signal, but the permissive signal. As he runs under the contactor there will be a blink of the light and a dropping of the white disk to indicate that his car has operated the relay counter. When the first car goes out of the block at the right end the signals are not changed,

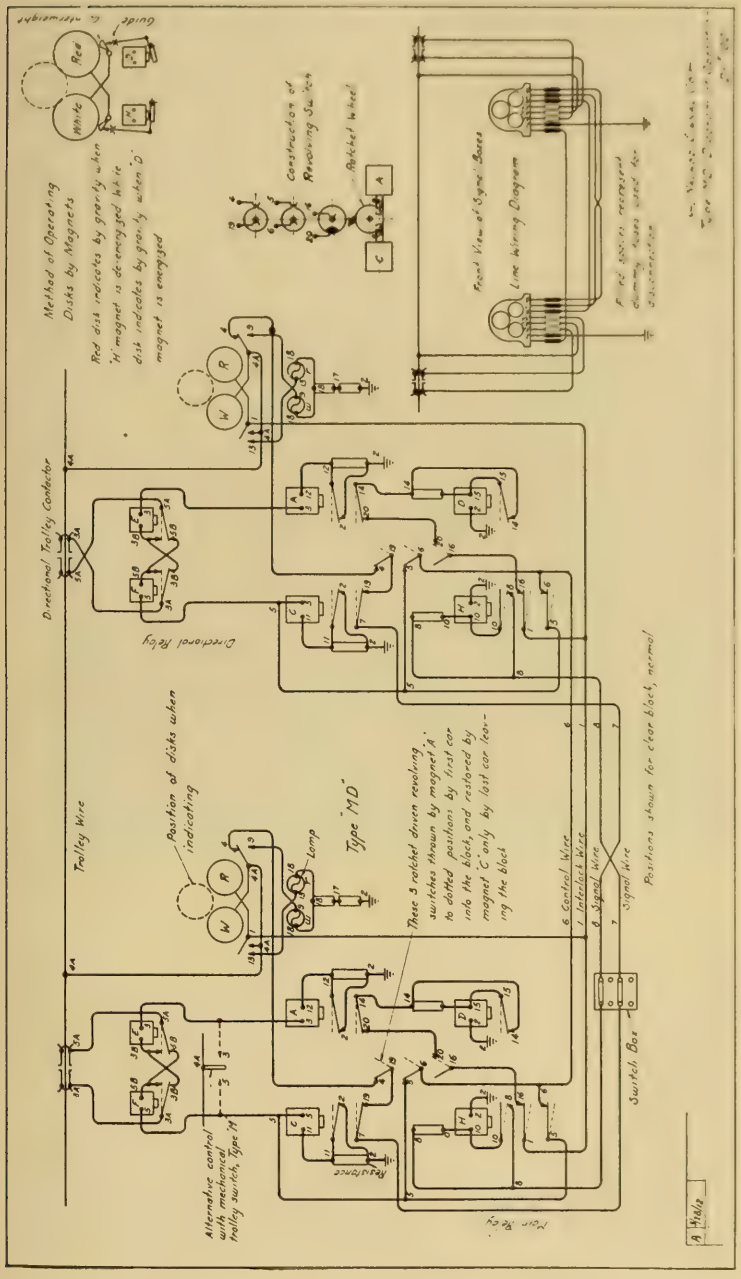

Method of Operating Disks by Magnets
Red disk indicates by gravity when 'R' magnet is de-energized while disk indicates by gravity when 'G' magnet is energized
Construction of Revolving Switch
Ratchet Wheel
Front View of Signal Boxes
Line Wiring Diagram
Directional Trolley Contactor
Directional Relay
Trolley Wire
Position of disks when indicating
Lamp
Type "MD"
Three 5 ratchet driven revolving switches thrown by magnet 'A' to dotted positions by first car into the block, and restored by magnet 'C' only by last car leaving the block
6 Control Wire
1 Interlock Wire
8 Signal Wire
7 Signal Wire
Positions shown for clear block, normal
Switch Box
Alternative control with mechanical trolley switch, Type "M"
Resistance
Main Relay
8 Volts

FIG. 34. WIRING DIAGRAM FOR SIGNAL LAYOUT.

FIG. 35. LINE WIRING DIAGRAM FOR SIGNAL BOXES.

but when the second leaves, they will be restored to normal. Should a car enter the block say from the left, setting the signals, then in backing out under the same contactor again, it will clear them. Should a car enter an occupied block against a stop signal, the signal at the other end will be set at stop also, and when the car wrongly entering the block backs out again, the signals will be restored to their previous condition as before its entrance.

Referring to Fig. 34 the electrical operation of the signal is as follows: In the normal condition of the block with signals neutral, that is, no

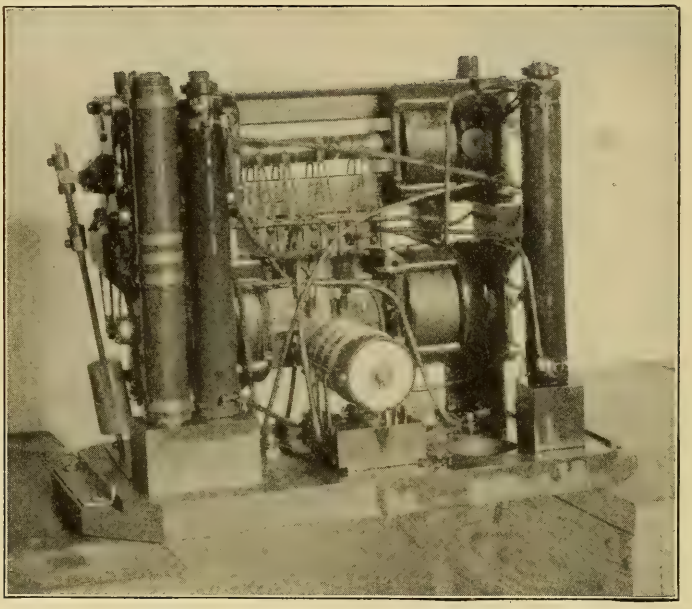


FIG. 36. REAR VIEW OF OIL-IMMERSED RELAY UNIT, INVERTED.

lights nor disks showing, the red disk R is prevented from indicating by the continuous energization of the H magnet in each relay, a separate signal wire 7 or 8, and revolving switch 19–4 being used for each stop signal. A car entering the block sends a momentary current through coil A by means of a mechanical trolley switch or by the trolley contactor and directional relay, breaking the circuit at the near relay of the H magnet in the far relay. The far signal therefore goes to the stop indication by gravity, showing a red disk and red light, and when it has done so, closes a circuit through the interlock wire 1, and the magnet D, which exhibits the white disk and white light as a proof that the red disk is showing. The lamps are operated

by the disks in such a manner that when the disk comes to an indicating position the circuit of the corresponding lamp behind a semaphore lens is closed.

The arrangement of clearing the signals or restoring them to the normal neutral position by means of No. 6 control wire and magnet C, after they have been set as described, is general; and a car or cars in the block may leave by either end singly or in any combination, the signals showing neutral only when all the cars that have entered the block have left it. Moreover, since the circuits for displaying stop signals are in duplicate and independent, it is evident that cars may reach opposite ends of the block at the same or successive instants with precisely the same ultimate effect on the signal. Also the clearing arrangement is such that when a car enters the block against the stop signal, thereby setting a stop signal at the opposing end, on backing out it will restore the signals to the same condition as before its entrance.

This results in the following desirable and highly universal operation: Should a car enter a block, having set signals, and remain there, then cars entering and backing at either end — whether against the permissive signal or the stop signal — will not change the stop signal as set by the first car in the block. After all the cars have left except the first one, when that one leaves the block the signals will be restored to normal.

The relay unit as shown in Fig. 36 is an assemblage of four magnets and three resistance units mounted on a terminal board and connected to the outside wiring by spring contacts. The upper pair of magnets move the revolving switch through a ratchet and pawl mechanism and serve to count the cars in the block. The lower pair drive the color disks. All the magnets operate switches in addition. The relay is bolted to the cast-iron upper case containing the signal indications and hangs in a tank of transformer oil. The entire unit is always lubricated, protected against corrosion and cushioned from violent magnet blows by the oil. It is oil cooled, oil insulated, and the switches are oil break.

With these general remarks the circuits will be described in further detail:

The term front contact is used to denote a contact made by an armature when its operating coil is energized, as, for instance, the front contact 1–16 operated by coil H. A back contact is one in which the contact is made when the armature falls away, the coil being de-energized, as 10–8. Also an indicating contact or switch is one closed by the color disk in its indicating position as 4A–10 on the white disk, a non-indicating contact being one closed when the disk does not show as 4A–4.

The direction of cars may affect the signals appropriately by causing them to energize magnet C or A, respectively; and this selection

Fig. 37. Trolley Contactor, Side View.

may be made either mechanically, by a trolley switch in which a lever is struck by the trolley wheel itself, its movement making one or the other of two electrical contacts, or by an electric selector, comprising the directional trolley contactor shown, without moving parts, and acting in conjunction with a directional relay having coils E and F. As this directional relay form a separate unit, and could be applied in other situations than here shown, it will be described separately.

The directional trolley contactor, Fig. 37, consists of two longitudinal sections or halves, each consisting of a pair of strips insulated from the trolley wire, but supported near it so that a metallic trolley wheel riding on the wire will connect the strips with the wire by means of its flange. The two halves of the contactor at the insulation are placed so closely together that for an instant the trolley wheel bridges both halves. The wheel does not leave the wire, but touches one or both of the flared and inclined contact strips, which, in order to prevent blows at high speed and to maintain a continuous contact, are flexible in themselves and flexibly mounted. The attachment of the contactor to the wire is by standard ears and suspension; and the insulation is through impregnated hickory. It operates the signals at speeds of 55 miles per hour. When a car passes in such a direction that the wheel reaches the end (see Fig. 34 and 35) 3A first, a circuit is formed from the trolley wire 4A, strip 3A, back contact 3B, terminal 3B, terminal 3 of coil E to the operating coil A, thence to ground. During this period the armature of coil E is attracted, changing the connection of 5A from 5B to 3B. Then when the car reaches the second half of the contactor 5A, the current continues from trolley wire 4A, wire 5A, front contact 3B, through the same coil E and to operating coil A as before. It will be noted that no current is broken at the back contact 5B, the only requirement being that E must attract its armature before the car reaches the end 5A of the contactor. Since these connections are exactly symmetrical for coil F, it follows that a car running under the contactor so as to touch 5A first will thus energize operating coil C; and

by attracting the armature of F will continue to energize that coil when the wheel reaches the second strip 3A.

All letters and numbers referring to the right-hand signal are distinguished by a prime letter or numeral, as 2′, in the following description:

When the signals are neutral there is a circuit from the trolley wire 4A, non-indicating switch 4A-4, revolving switch 4-19, back contact 19–7, through a switch box, if one is used, to signal wire 7, entering the other signal relay as 8′, resistance 8′–10′, through coil H′, by terminals 10′, 2′, to ground 2′. By use of a switch box a track switch not having its points completely closed will set stop signals at both stations.

A car entering the block from the left closes the local circuit from trolley 4A through coil A, as described, terminal 12, back contact 2, ground 2. The armature of coil A rotates the revolving switch one notch, throwing it into the dotted position, and breaking the aforementioned circuit through the H′ magnet at the revolving switch 4-19. The armature of H′, being de-energized, falls, and the red disk appears by gravity. When it reaches the indicating position, the indicating contact 4A′–1′ is closed; current then flows from trolley through 4A′–1′ through the interlock wire 1 to the other box, front contact 1–16, revolving switch 16–20, back contact 20–14, resistance 14–15, terminals 15, 2 of coil D, to ground 2. Coil D is thereby energized, attracting its armature and displaying the white disk W, which on indicating closes the indicating switch 4A–9, and lights the white lamp, Thus by switch 4A′–1′ the white disk is interlocked with the red, so that if the red disk should stick in the non-indicating position, the magnet D would not be energized, nor would the white disk indicate. Moreover, it will be evident that this interlocking is mutual; and if, for instance, the white disk W should stick in the indicating position irrespective of the state of coil D, or be raised by hand to that position, then the H′ magnet would be de-energized by the opening of the non-indicating switch 4A–4 and exhibit the red disk R′. Furthermore, should the H magnet fail on a clear block, either by open circuiting or short circuiting, its armature thereby dropping, the red disk in that box will be displayed, but the corresponding white disk in the other box will not be displayed, since that circuit is open at the revolving switch 16′–20′. The foregoing comprise the safety circuits.

Every impulse of current in the magnet A, as by a car passing the contactor to enter the block, rotates the revolving switch one notch in the clock-wise direction, and every impulse of current in coil C, as by a car leaving the block, rotates this switch one notch in the counter clock-wise direction. Therefore, if the signals were neutral with no car in the block, after all the cars that have entered the block have vacated it, they will again assume the neutral position. The clearing magnets C and C′, with the control wire 6 and its associated revolving

switches 5–6 and front contacts 5–6, are used to control the restoration of the signals.

Thus a car going straight through the block from left to right will set permissive signals at the entering end, and stop signals at the leaving end. As it leaves the block at the right-hand contactor, it will, it is true, close a local circuit through coil C′, but this will have no action on the revolving switch, since there is a mechanical stop at its initial position. Current will, however, continue by wire 5′ through revolving switch 5′–6′, through control wire 6 to the left-hand signal, thence by means of front contact 6–5 to coil C. The action of this magnet is to restore the revolving switch to its original position, closing contacts 4–19, and opening the circuit of magnet D at 16–20. This magnet being de-energized, the white disk is restored to the non-indicating position, closing the non-indicating switch 4A-4. The circuit through the H′ magnet is thereby established at 4A–4 and 4–19 as described; the H′ magnet restoring the red disk R′ to the non-indicating position. The latter action extinguishes the red right.

Should, however, a car enter the block from the left and back out again under the same contactor, in backing out it will close a local circuit through coil C as described; and, although by means of wire 5, front contact 5–6, control wire 6, and revolving switch 6′–5′, current will also energize coil C′, there will be no rotation at the revolving switch here on account of the mechanical stop. Current passing through coil C will restore the revolving switch to its original position, thereby restoring the signals to neutral, as already described.

Should a car enter, say from the left, setting the signals, and a car enter from the right against the stop signal there displayed, then the revolving switches in both relays will be rotated to the dotted position, coils H and H′ will be de-energized, and stop signals will show in both stations. (When the red disk indicates at a signal, the white disk cannot be displayed there at the same time, since the display of the red opens the circuit of the D magnet at the front contact 1–16. Moreover, the red disk is in front of the white disk and would eclipse it if both were raised by hand.) When the right hand car backs out of the occupied block, it will energize coil C′ to close the revolving switch at that box only, thereby restoring the signals to the same condition as before its entrance. In energizing coil C′ there will be no circuit through the control wire 6 to magnet C in the other box, because revolving switch 6–5 is open, and front contact 6–5 will not be closed while the car is on the contactor.

The holding open of the back contact 7′–19′, which is in the circuit of the H magnet, by the presence of the car on the contactor, will prevent the closing of the above-mentioned front contact 6–5 by the H magnet.

The new type "MD" signal will be used on the Moosic Lake division of the American Railways Company's property at Scranton, Pa.

INSTALLATION BY THE UNITED STATES ELECTRIC SIGNAL COMPANY

This company has furnished the following list of roads which purchased its signal apparatus during 1911:

Name.	Number of Signals.
Albany Southern R. R. Co.	4
American Rys. Co., (The)	2
Aurora, Elgin & Chicago R. R. Co.	2
Bay State St. Ry. Co.	20
Birmingham Ry., Light & Power Co.	4
Boston Elevated Ry. Co.	4
Charleston Cons. Ry. & Lighting Co.	4
Choctaw Ry. & Lighting Co.	12
Crossman & Sielcken (New York, N. Y.)	16
Dallas Cons. Elect. St. Ry. Co.	4
Elmira, Corning & Waverly R.R.	16
Guinle & Co (for Campanhia Linha Circular Bahia, Brazil) New York, N. Y.	12
Holyoke St. Ry. Co.	18
Hudson Valley Ry Co.	4
Illinois Traction System	2
Indianapolis Traction & Terminal Co.	4
Knoxville Ry. & Light Co.	1
Manila Elec. R. R. & Light Co. (Manila, P. I.)	12
Middlesex & Boston St. Ry. Co.	2
Milford, Attleboro & Woonsocket St. Ry. Co.	12
Nashville Ry. & Light Co.	2
Niagara, St. Catharines & Toronto Ry. Co (St. Catharines, Can.).	2
Norfolk & Portsmouth Trac. Co.	2
North Jersey Rapid Transit Co.	4
Orange County Traction Co.	24
Pan-Handle Traction Co.	12
Portland Ry., Light & Power Co.	18
Public Service Ry. Co.	399
Quebec Ry., Light & Power Co. (Quebec, Can.)	2
Rio de Janeiro Tram. Light & Power Co. (Rio de Janeiro, Brazil).	60
Rockland, Thomaston & Camden St. Ry. Co.	2
Springfield St. Ry. Co.	22
Steubenville & Wheeling Trac. Co.	1
Susquehanna Ry. Light & Power Co.	4
United Traction Co. (Albany, N. Y.)	2
Watlington & Co. (London, Eng.)	40
Westchester Electric Railroad Co.	2
Worcester Consolidated St. Ry. Co.	58

Installation of Simmen Signal Equipment on the Indianapolis & Cincinnati Traction Co.*

In May, 1912, the Indianapolis & Cincinnati Traction Company, Charles L. Henry, president, put into service a manually operated, remotely controlled interlocking signal system designed and installed by P. J. Simmen of Northey–Plummer, Ltd., Indianapolis and Toronto. This system affords means by which the dispatcher can, as a train approaches, passes or leaves a siding, display stop, proceed or caution signals to the motorman. These signals are displayed by illuminated dials inside the cab directly in the motorman's view. The signal transmitting apparatus is interlocked so that it is mechanically and electrically impossible for the dispatcher to give signals corresponding to a lap order. Another strong feature of this system is that a permanent record is continually drawn before the dispatcher showing at all times the position and direction of the movement of all trains. This system of signaling has been in satisfactory operation on the Toronto & York Radial Railway for three years, controlling trains under 20–minute headway.

The Indianapolis & Cincinnati Traction Company installation includes protection for nine blocks and ten sidings, each block extending from siding to siding and averaging about two miles in length. The most attractive features of this system are its simplicity, flexibility and elasticity. The principal mechanical and electrical circuits consist each of an iron wire connecting short sections of third-rail at the sidings with relays and small switches and a battery in the dispatcher's office. The return circuit is over the track rails. The system is designed on the normal danger plan; that is, if any part of the apparatus becomes deranged stop signals are displayed. The apparatus on the car is very simple. In consists only of a third-rail shoe for making contact with the short signal rail, a relay and a small local battery for supplying energy to the signal lamps. Either a clear or a stop signal is always displayed before the motorman.

The Indianapolis & Cincinnati Traction installation includes no change in principle from that underlying the installation which has operated so satisfactorily for three years on the Toronto suburban lines.

PRINCIPAL PARTS OF THE SYSTEM

The principal parts of this system consist of a main control circuit leading from the dispatcher's office to each siding, a switch relay and battery connection in the dispatcher's office for each control circuit, three short (about 75 ft. long) sections of contact rail for each siding and a contact shoe relay, local battery and two (red and green) light

* The following description is an abstract of an article appearing in the *Electric Railway Journal*, June 8, 1912, page 968.

signals on each motor car. The control line for each siding is independent of the other control lines except that all of the dispatcher's switches (one in each control circuit) are mechanically interlocked.

Main Signal Circuit

One independent signal wire connects the three contact rails at each siding direct with the dispatcher's switchboard and the return circuit is made through the track rails, which do not need to be cut at the siding. For the main signal circuit on this 18 mile installation about 100 miles of line wire have been erected. This wire is No. 14

FIG. 38. SHOWING SIGNAL CONTROL BOARD, TRAIN-RECORDING APPARATUS AND TELEPHONE SWITCHBOARD.

copper clad which was chosen of this size not because so great a conductivity was required but because it was thought this was the smallest wire that would serve mechanically. The short lengths of contact rail are located one opposite the switch and two others, 2,000 ft. distant in each direction. The rail at the siding is called the home rail and the other two are called distant rails. By means of the two rails located 2,000 ft. from the siding it is possible to inform the crew of its signal, sufficiently far in advance to permit the stop to be made before the siding is reached. That is to say, if two trains are approaching a siding where they are to meet, they will receive red signals when 4,000 ft. apart and each train will yet have 2,000 ft.

distance remaining in which to come under control to make the siding stop.

The three short pieces of third-rail at the siding are electrically connected by the single line wire and this wire without other connection extends along the pole line direct to the dispatcher's office. This forms the main circuit for the siding. The circuit on entering the dispatcher's office, passes through a knife switch, then through a fused lightning arrester and then through a 300-ohm relay mounted on the top of the dispatcher's control switch and thence through a common 30-volt battery to a ground on the track rail.

One of these main control circuits is installed for each siding and only the parts enumerated are in circuit at any time. Each main control circuit normally is open at the track end, the opening occurring between the track rail and the short contact rail. When a car passes, the contact shoe attached to the side of the truck touches the third-rail. The circuit is then completed through a relay on the car and through the running gear of the gear to the rail. Thus the car relay is put in series with the relay and the dispatcher's control switch at the central office.

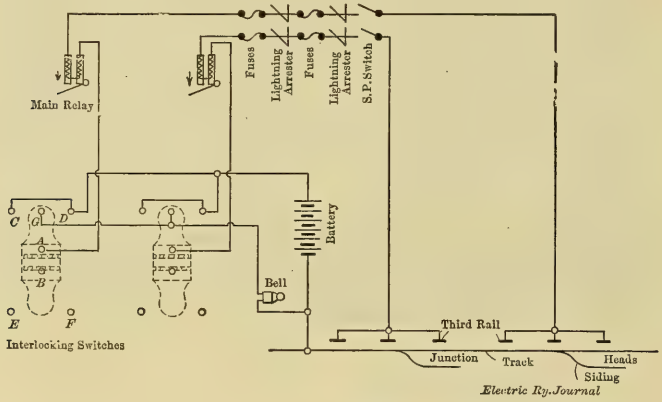


FIG. 39. SHOWING DIAGRAM OF TWO MAIN CONTROL CIRCUITS.

The only part of the apparatus in this main circuit with which the dispatcher has anything to do in normal operation is the small control switch on his board by which the circuit can be opened or closed. There are ten of these switches in this signal installation, one controlling the main circuit leading to each of the ten sidings which protect the nine blocks. This switch consists of a single steel stem on which are mounted an interlocking segment and a contact piece which, as the switch is revolved through 45 deg., makes contact with either of three similar contact pieces fixed on a slate panel.

Control Switches

There is a dispatcher's switch for controlling the circuit leading to each siding. The position of the switch handles indicates the signal that will be displayed on a car when its shoe touches any one of the three short sections of contact rail at or near that siding. The row of switches controlling the signal indications at each siding is so interlocked that both eastbound and westbound trains cannot be given clear signals for the same block. The nearest to each other that they can approach under clear signals is 4000 ft., or each train 2000 ft. distant from the same siding, when each will receive a red signal and have ample distance in which to stop before reaching the siding.

The psychological effect of placing before the dispatcher a continuous indication as given by the position of the switch handles, of the running rights of all trains anywhere on the road, is a most important feature of this signal system, especially when this feature is supplemented by a continuous record sheet indicating the position, direction and speed of all trains at all times.

Car Equipment

The simplicity of the local circuit on the car is apparent when it is stated that this circuit includes only one relay, one local battery, two signal lights and a ruggedly constructed third-rail contact shoe. Each motor carries two ground-glass signal dials mounted, one above the

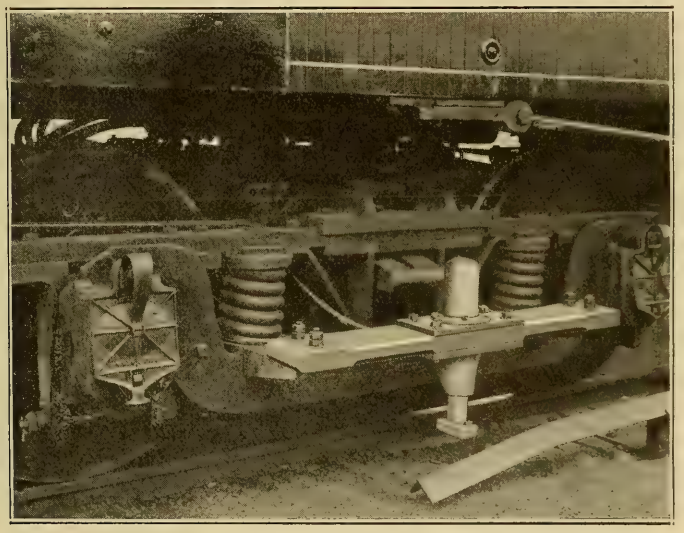


FIG. 40. SHOWING THIRD-RAIL CONTACT SHOE.

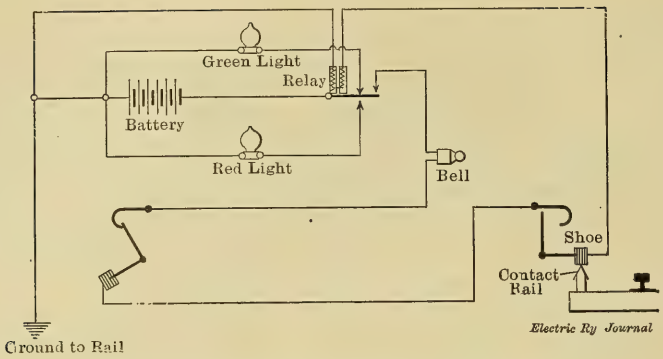


FIG. 41. SHOWING DIAGRAM OF CAR CIRCUIT.

FIG. 42. SHOWING CAB INDICATOR SIGNAL.

other, on a substantial frame attached to the window post in front of and just to the left of the motorman's position, as shown in an accompanying view. One signal glass is red; the other is green. Both are provided with small incandescent lamps for illumination. Energy for these lamps is furnished by a small local battery. The other apparatus on the car, as shown by the circuit diagram, consists of a relay with two back contacts and one front contact, and a contact shoe which is attached to the truck equalizer beams, as shown in Figs. 40 and 41.

The principle of this cab signal is that if a contact rail is energized (by the closing of the dispatcher's control switch), then a passing train will receive a clear signal; if the contact rail is de-energized (purposely by the dispatcher opening the control switch, or because of a line wire derangement), then a passing train will receive a stop signal. A clear signal will continue to show while running through the block, and a stop signal, once displayed, will remain displayed until the car reaches an energized contact rail. This set of circumstances in connection with the interlocking features of the signal system provides for extreme flexibility in the handling of trains in sections at passing and meeting points.

This system is designed to do the work not only of an automatic block system but also of the so-called "dispatcher's" signal system, because the dispatcher may at any time stop any train at any siding.

Train Record Sheet

The record sheet is directly driven through a worm and ratchet movement which is operated every five seconds by a pair of magnets controlled by a carefully adjusted block movement. The vertical scale on the record sheet, one inch, equals ten minutes, and the horizontal scale is subdivided according to distance. The subdivisions are made by continuous vertical lines, the space between any two adjacent lines representing, proportionately, the distance between these two sidings. The record sheet is so arranged in its moving mechanism that about two hours' performance is always visible to the dispatcher so that he can see the changes that are being made in the record as they occur.

The movement of trains is recorded on the sheet by needle punches, and whenever a train passes a contact rail slits are cut in the paper. The ends of the slits show the time a train enters and leaves each block. The punches are made by needles mounted above the record sheet and the slits are made by needles mounted below the sheet. They are called "top" and "bottom" needles. Each needle is actuated by an electromagnet and these magnets are energized through front contacts on the relays in the dispatcher's control circuits.

The essential features of the Simmen record system are the main control line relay and the single-punching top needle. The line-cutting bottom needles are used as refinements to make the records more readable. This simple circuit with its top needles and local battery con-

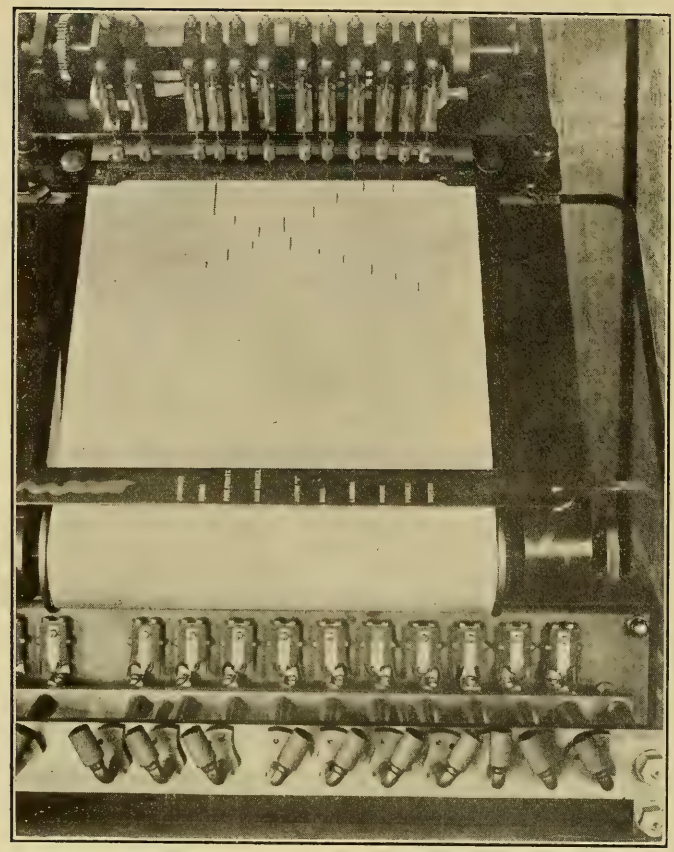


FIG. 43. SHOWING RECORD SHEET IN SERVICE, WITH RECORDS MADE BY TWO OPPOSING TRAINS.

trolled by the front contacts on the main relay in the main line control, would serve to give all the indications required for a complete signal system. However, additional features are added to enhance the legibility and value of the record and to increase the flexibility of train control. The chief feature for obtaining these supplementary results is a set of magnet-operated needles which perforate the paper from below and in contrast with the top needles which merely make a dot, the bottom needles cut a line in the paper recording the full time which a train occupies in running through a block. The time of arriving and leaving at the division point between the blocks is indicated as well as the time used in passing through the block.

The record sheet also checks the dispatcher and shows just how the switches have been set for all train movements, the location of the lines in the columns indicating whether the switch was set for eastbound or westbound movement.

Operating Features

The signal system has no connection at all with the car-propulsion current supply, and thus when the power goes off from the transmission line there is no reason why cars cannot coast down hill or proceed under any momentum that they may have and thus be able to save some time.

All the testing work necessary in connection with obtaining high continuity of service from this signal system can be done in the dispatcher's office. Open-switch protection has been provided at low cost with the Simmen signal system by placing a standard switch circuit controller so that it will be operated by the movement of the switch-point and when the switch is set open the controller will open the line which connects the contact rails with the dispatcher's office. Thus approaching trains may receive stop signals when 2000 ft. away from an open switch.

With regard to maintenance of the signal system, it is noted that all of the pieces of apparatus are located either in the dispatcher's office or in the cab of a car, the two places on the road where they can most easily and economically be inspected.

Installation of the Automatic Signal and Appliance Co.

The system for single track work comprises two contactors, two signal boxes and a master controller. Contactors operate at any speed, and are set about 700 feet in advance of the signal. As car approaches a clear block displaying green light and semaphore arm at clear or perpendicular position and passes on under contactor it throws the signal at the far end of the section or block to "stop" position. This operates an interlocking circuit which drops the signal the car is approaching to "caution" or "middle" position, displaying a yellow light, at same time the master controller counts one car in the block. As the second car passes the entering contactor the lamp in the signal box that the car is approaching is extinguished, and the hood rises for about five seconds, giving the motorman indication that the contactor is working and that the master controller has likewise counted his car or train into the block. As the cars leave the block they are counted out until all cars have cleared when the signals assume the upright or cleared position.

Spacing signals and contactors are similar to the ones heretofore described. The contactor being set about 100 feet in advance of semaphore, as car passes under same it throws semaphore to stop position.

When car has cleared the section which is being protected another contactor is passed which clears up the semaphore permitting the next car to pass through the protected section.

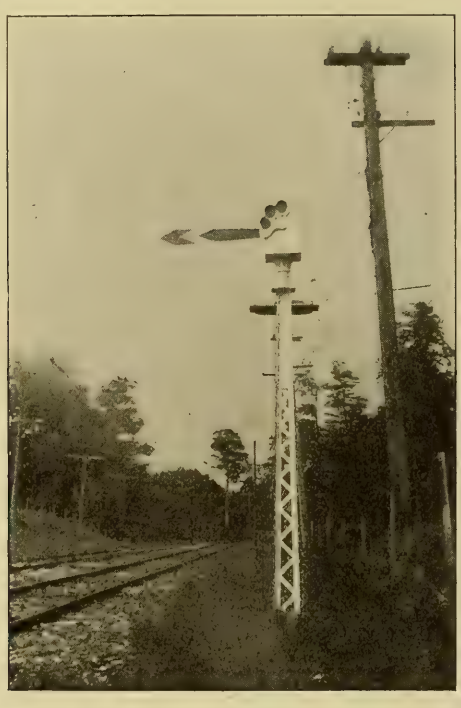


FIG. 44.— SHOWING SPACING SIGNAL AS USED ON DOUBLE TRACK OF THE LAKE SHORE ELECTRIC RAILWAY.

Railway Signal Association standard semaphores are used and one 40 watt tungsten lamp burns continually. The resistance in series with this lamp keeps all the working parts warm in cold weather as the lamp and resistance are enclosed in the signal box. The lamp is so wired that in case it should burn out another lamp of lower voltage immediately cuts in to take its place.

The Figs. 45 and 47 show both ends of single track section on the Lake Shore Electric Railway at Vermilion, O., with a car entering the block from the east, signal having moved to the middle position. The iron box on pole (shown also in Fig. 44) at west end of block contains the master controller which counts the cars in and out of the block.

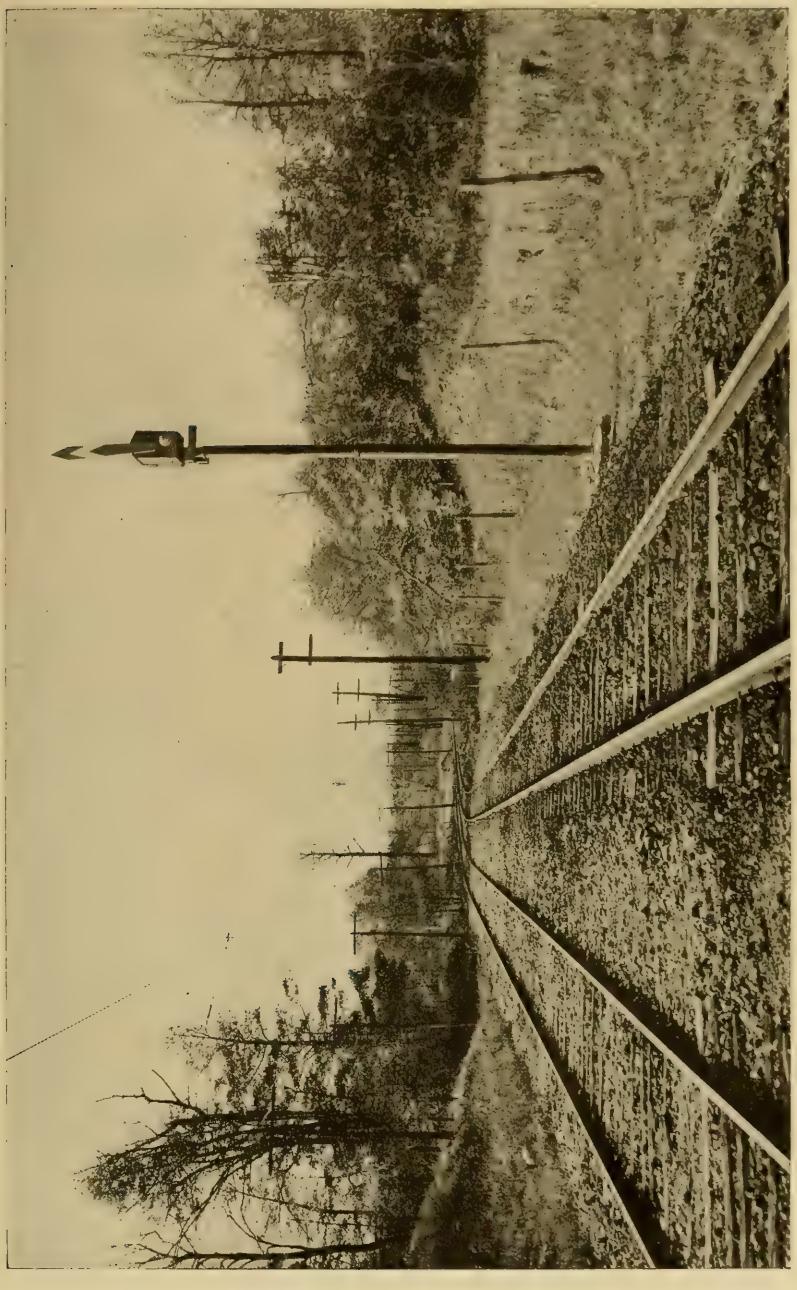


FIG. 45.— SHOWING BLOCK SIGNALS ON LAKE SHORE ELECTRIC RAILWAY.

Three wires are required between signals and the master controller. These signals are operated daily by cars running at 60 miles per hour or more as they approach the block from the west entering the town of Vermilion.

The contactor as shown in Fig. 46, is so arranged that it has no moving parts to come in contact with the trolley wheel, in case a car

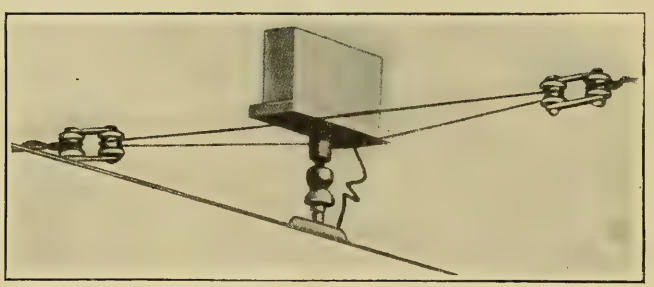


FIG. 46.— SHOWING TROLLEY CONTACTOR.

should coast under it while power is off the line it leaves the switches in contactor set so the signals immediately show the location of the car that coasted under the contactor when the power comes back on the line. A car can stand under the contactor without damage to it or the car.

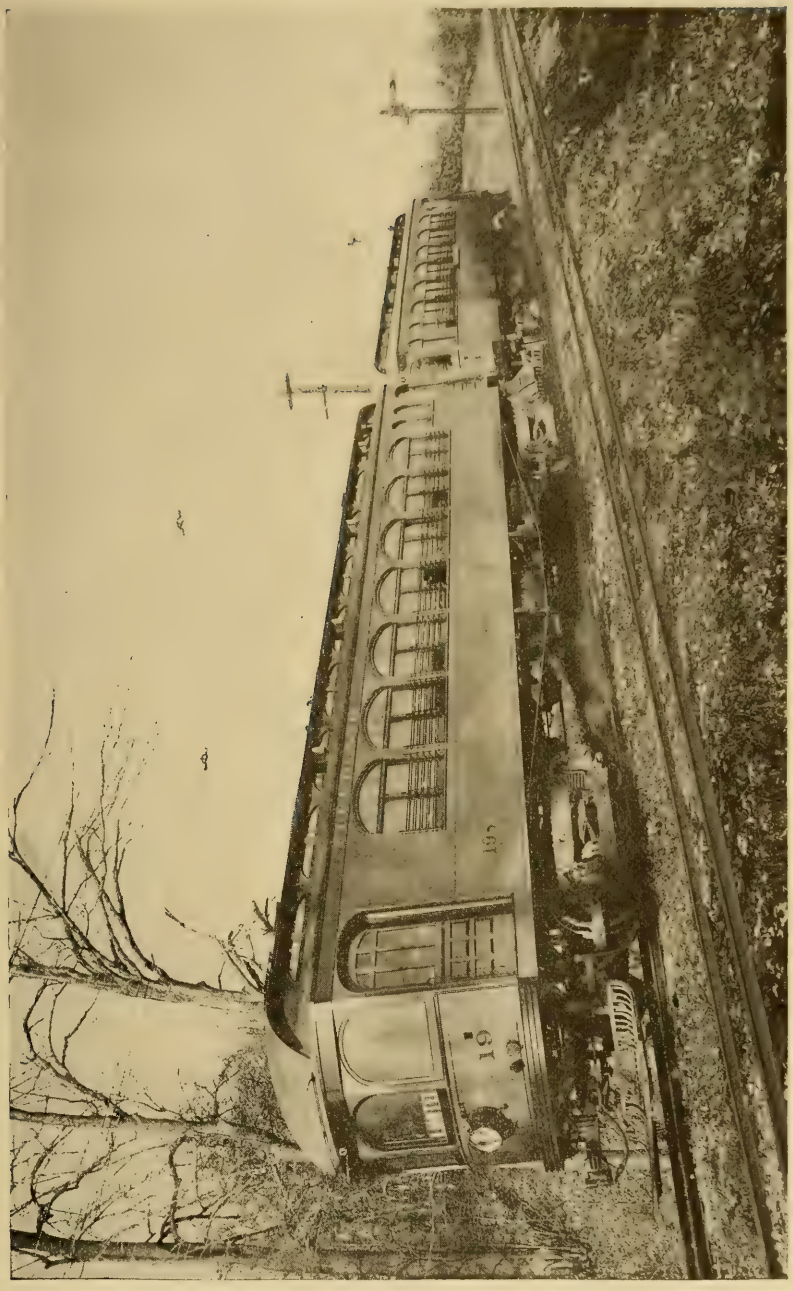


FIG. 47.— SHOWING CAR ENTERING BLOCK ON THE LAKE SHORE ELECTRIC RAILWAY.

APPENDIX B

SIGNAL LOCATION AND ARRANGEMENT.

In reporting on that part of the report of the 1911 Committee in which it was requested that numerous signal layouts be given to meet the requirements as outlined for five different conditions of traffic; it was thought best to confine this report to describing the signal arrangements as now in use on several prominent interurban roads. This was done on account of the large number of varying factors entering into each particular case, making the arrangement of signals on each road a study in itself, affected only generally by what has been done on some other road. In addition to the above mentioned descriptions, a few of the principles affecting the location of signals on a single track railroad are also given.

In the majority of interurban roads to be signaled the traffic will rarely be dense enough to make necessary the dividing of the distance between sidings into supplemental blocks in order to facilitate train operation, therefore only such arrangements where a block extends from one siding to the other will be considered.

As a method of illustration the two signals as used for protecting a dangerous curve, will be considered. Signals are usually, where possible, placed upon the right hand side of the track looking in the direction of the traffic which they govern; therefore in Fig. 46, Signal

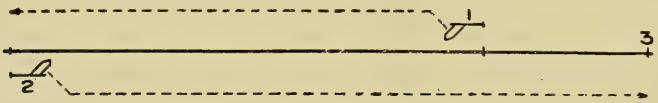


FIG. 48.— CURVE PROTECTION.

1 governs west bound cars and Signal 2 east bound, the dangerous or obscured track lying between the two signals. The space between the two signals is called a block. The dotted lines show the control limits of the two signals, or in other words, the extent of the track which controls the signals. For instance, a car anywhere between Signal 2 and point 3 will cause Signal 2 to remain in the "Stop," horizontal position, while Signal 1 is affected only when the car is between Signals 1 and 2.

Were Signal 2 controlled only up to Signal 1, it would then be possible for two cars to simultaneously pass Signals 1 and 2 each receiving a proceed indication. This must, of course, be avoided and it is usually accomplished by the use of a setting section, or preliminary, extending beyond one of the Signals, as 1–3. By the use of this preliminary a car running west sets Signal 2 to stop after passing point 3, and in case an east bound car has not already passed Signal 2, it

would be stopped by it. In case, however, the east bound car had passed Signal 2 before the one west bound passed point 3, Signal 1 would be set to stop, being controlled to Signal 2, and the west bound car would be stopped at Signal 1. It must be understood that the fact that Signals 1 or 2 be in the proceed position gives the governed car the right to proceed only up to the opposing signal, or through the block, for if, as in the last mentioned case, an east bound car passes Signal 2 before the west bound car passes point 3, the latter will stop at Signal 1 and the opposing car, having had a proceed signal at 2, might meet with an accident. If a preliminary were used on both ends, or the control of each signal were extended out beyond the other, two opposing cars might get into the preliminary sections at the same time. In this event both signals would assume the stop position and neither car could proceed. It is therefore desirable to locate the signals, in a case of this kind, at least, braking distance from the point of curve so that in case one car is standing at a signal an opposing car rounding the curve will be able to stop before reaching the signal.

Should two following cars approach a protected curve close together, the second car would be stopped by the signal until the first car had passed beyond the limits of control of that signal.

In general, the description of a curve protection given above is the nucleus of the more complicated forms of siding protection, the principle being the same throughout and additions being made as the traffic conditions require it.

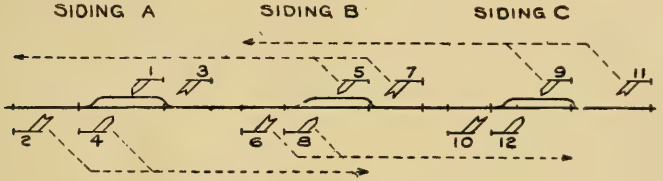


FIG. 49.— SIDING PROTECTION.

Referring to the layout in Fig. 49, which shows the arrangement used on one of the largest installations on an interurban railroad; the Signals 4 and 5, and 8 and 9 divide the section of track shown into two blocks, and each pair corresponds to the two curve protection signals in Fig. 48; in that there are two opposing signals with a setting section for each; the distance 2–4 being the preliminary for Signals 4–5; and 6–8 for 8–9; as shown by the dotted lines. With this arrangement a car passing Signal 2 sets Signal 5 to Stop, Signal 1 having already been set to stop from the siding off the print to the left.

It will be seen that the block 4–5 extends a short distance into the block 8–9 thus overlapping 8–5. This distance is what is known as an

overlap and in this case is the space separating two opposing cars when both have come to a stop at their governing signal.

The use of distant or caution signals, for controlling the approach of cars to the home signals; of switch boxes for setting signals to stop when a switch is misplaced, and of indicators for various purposes, are all side issues which may, or may not, be used according to the varying traffic conditions encountered.

Under certain conditions the two home signals such as 5 and 8 may be safely placed opposite in this way effecting considerable economy. When this is done, however, the location of the signals is a matter for careful consideration. For instance, in the following sketch a car in either direction entering the siding would with the signals as located in dotted lines affect the signals at each of the adjoining sidings, due to the necessity for this car to enter both track sections in order to get into the siding.

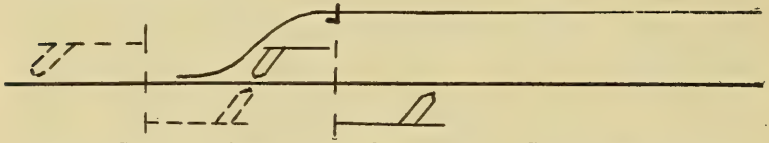


FIG. 50. SHOWING LOCATION OF SIGNAL WITH CAR ENTERING SIDING.

While, with the signals located as shown in full lines, a car can enter the siding from the left without affecting the signal at the next adjoining siding on the right, which is, of course, to be desired.

Among the various features entering into the subject of locating signals, the following are probably the most important:

The maximum braking distance of trains as affected by their speed and weight and by the grades encountered.

The locations of sidings, stations, curves and like physical features of the right-of-way.

The headway of trains to maintain the schedule.

The distance at which signals can be easily read and interpreted.

The "preliminary" section as described above should not ordinarily be less than 1000 ft., while 1500 ft. is to be preferred.

DESCRIPTIONS OF LAY OUTS SHOWN IN ACCOMPANYING FIGURES

Fig. 51 shows suggested arrangements of trolley contact signals, the signals being located about half-way between the point of frog and the point of switch so that they may be equally well seen from a car on the siding as well as a car on the main line.

The signal may or may not be designed to permit permissive following operation, that is, allowing one train to follow another into an occupied block under a special signal indication designed to show the motorman that the block is already occupied.

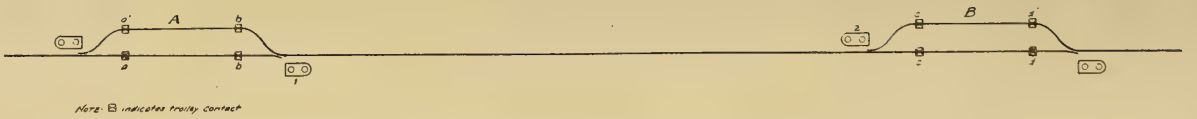


FIG. 51. SHOWING TYPICAL ARRANGEMENT OF SIGNALS WITH TROLLEY CONTACT.

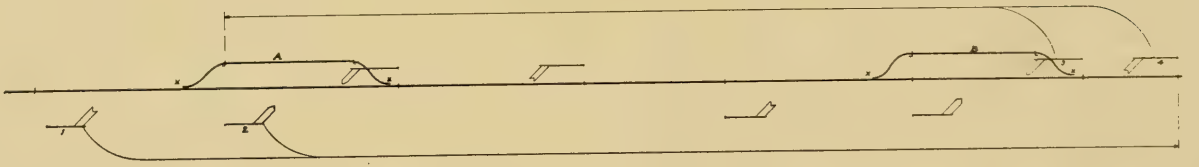


FIG. 52. SHOWING SIGNAL LAYOUT SIMILAR TO THAT INSTALLED ON THE ILLINOIS TRACTION SYSTEM.

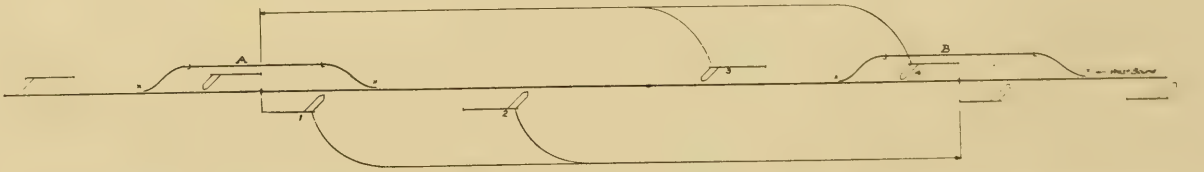


FIG. 53. SHOWING LAYOUT SIMILAR TO THAT INSTALLED ON THE WASHINGTON, BALTIMORE AND ANNAPOLIS ELECTRIC RAILWAY WITH THE EXCEPTION THAT SIGNALS 2 AND 3 WERE LIGHT SIGNALS.

The contactor should preferably be of the instantaneous type, that is, one in which the contact is immediately made and broken, in this way eliminating the danger of a double registration either into or out of the block.

The operation under the arrangement given is as follows: A car passing under contactor b when both signals are neutral causes a proceed indication to be given at 1 and a stop indication at 2. An opposing car approaching 2 should therefore stop before his trolley passed contactor c until the car bound from A to B passed into siding B and over contactor c; which would restore the signals to the neutral position. The car bound from B to A could then proceed under c setting 2 to proceed and 1 to stop. The second car, in the siding, could then either back out registering in as a second car when passing c and counting out again when passing c, or it could run through the siding to d′ and providing the signal was not at stop, could proceed under d′, observing the signal meanwhile and if the proper indication was received, proceed on its way.

With this arrangement it should be noted, however, that the track between contactors c and d, c′ and d′, and a and b and a′ and b′ is unprotected. Various other arrangements can of course be worked out to meet different operative conditions.

Fig. 52 shows the signal arrangement as installed on the Illinois Traction System. This includes four signals to each siding unit, two home and two distant signals for each.

The block is from 2–3 and the preliminary from 3–4. The preliminaries have in this installation always been placed on the south end of the siding, and the south bound home signals were placed at the fouling point of the siding instead of at the switch point. With this arrangement two opposing trains cannot get closer than the distance between home signals, which is approximately the length of the siding. All cars are compelled to head-in and back-out of all double end sidings. A car running from A to B may enter siding A without affecting Signal 3, as 3 is only controlled to 2. This allows a car running from B to A to proceed up to Signal 5 without being affected by the opposing car beyond 2. Considering now that siding B is a meeting point and the car approaching B from the right reaches Signal 4 before the opposing car passes Signal 2, if the former car proceeds past Signal 4 it will set Signal 2 to stop and hold car at this signal until the car near B reaches the siding and enters same. This would naturally delay the opposing car at A.

A rule has therefore been made that northbound cars (the preliminary is on the south end), approaching a meeting point and finding the distant signal clear, which indicates that the opposing car has not passed 2, must stop, and after waiting one minute call the dispatcher for orders as to a possible change of meeting points. With a reasonably close meet the car at A will have passed Signal 2 before the

opposing car reaches Signal 4, so that neither car is stopped until siding B is reached. The first car to arrive takes the siding, heading in and closing the switch. This clears the signal at the opposite end of the siding and the opposing car proceeds. The car in the siding then backs out and receiving a clear home signal proceeds. A southbound car reaching the meeting point and entering the siding before the northbound car comes into view, must keep the switch set for the siding so as to hold the northbound distant signal at caution until the northbound car passes it, the switch may then be closed, which clears the home signal and allows the northbound car to proceed without delay.

Fig. 53 shows the arrangement of signals in the recent installation on the Washington, Baltimore & Annapolis. This is rather novel in that there is but one circuit from siding to siding and no real preliminary is used, the block extends from 1 to 4 and in order to prevent two cars passing these signals at the same instant and both getting clear signals, advance Signals 2 and 3 are used so that if this were to occur both cars would be stopped at Signals 2 and 3 respectively.

Considering siding "B" as a meeting point, cars may approach from either direction up to Signal 4 without affecting the adjacent signals in any way. At the double ended sidings either car may enter the siding and allow the opposing one to proceed, while at single ended sidings that car facing the point of the switch should take siding, the other car standing on the main track back of the signal until it assumes the proceed position.

APPENDIX C

COMPANIES REPLYING TO DATA SHEET 90

1. Albany Southern Railroad Co., Albany, N. Y.
2. Altoona and Logan Valley Electric Railway Co., Altoona, Pa.
3. Aurora, Elgin and Chicago Railroad Co. (The), Wheaton, Ill.
4. Austin Street Railway Co., Austin, Texas.
5. Bangor Railway and Electric Co., Bangor, Me.
6. Bay State Street Railway Co., Boston, Mass.
7. Birmingham Railway, Light and Power Co., Birmingham, Ala.
8. Boston Elevated Railway Co., Boston, Mass.
9. Bucks County Electric Railway, Newtown, Pa.
10. Capital Traction Co. (The), Washington, D. C.
11. Central Pennsylvania Traction Co., Harrisburg, Pa.
12. Chicago, Lake Shore and South Bend Railway Co. (The), Michigan City, Ind.
13. Chicago, South Bend and Northern Indiana Traction Co., South Bend, Ind.
14. Chippewa Valley Railway, Light and Power Co., Eau Claire, Wis.
15. Cincinnati, Lawrenceburg and Aurora Electric Street Railroad Co. (The), Cincinnati, Ohio.
16. Denver City Tramway Co. and Denver and Northwestern Railway Co., Denver, Colo.
17. Duluth Street Railway Co. (The), Duluth, Minn.
18. Easton Transit Co., Easton, Pa.
19. Elmira Water, Light and Railroad Co., Elmira, N. Y.
20. Evansville Railways Co., Evansville, Ind.
21. Fairmont and Clarksburg Traction Co., Fairmont, W. Va.
22. Fonda, Johnstown and Gloversville Railroad Co., Gloversville, N. Y.
23. Fort Wayne and Northern Indiana Traction Co. (The), Fort Wayne, Ind.
24. Galesburg and Kewanee Electric Railway Co., Kewanee, Ill.
25. Hartford and Springfield Street Railway Co., Warehouse Point, Conn.
26. Illinois Traction System, Peoria, Ill.
27. Indiana Union Traction Co., Anderson, Ind.
28. Ithaca Street Railway, Ithaca, N. Y.
29. Iowa and Illinois Railway Co., Davenport, Iowa.

30. Kansas City-Western Railway Co. (The), Leavenworth, Kan.
31. Kingston, Portsmouth and Cataraqui Electric Railway Co., Kingston, Ont.
32. Knoxville Railway and Light Co., Knoxville, Tenn.
33. Kokomo, Marion and Western Traction Co., Kokomo, Ind.
34. Lackawanna and Wyoming Valley Railroad Co., Scranton, Pa.
35. Lehigh Valley Transit Co., Allentown, Pa.
37. Louisville Railway Co., Louisville, Ky.
38. Lynchburg Traction and Light Co., Lynchburg, Va.
39. Metropolitan Street Railway Co., Kansas City, Mo.
40. Milford and Uxbridge Street Railway Co., Milford, Mass.
41. Morris County Traction Co. (The), Morristown, N. J.
42. Muncie and Portland Traction Co., Portland, Ind.
43. New Jersey and Pennsylvania Traction Co., Trenton, N. J.
44. New York State Railways, Rochester, N. Y.
45. Northwestern Pennsylvania Railway Co., Meadville, Pa.
46. Omaha, Lincoln and Beatrice Railway Co., Lincoln, Neb.
47. Pacific Gas and Electric Co., Sacramento District, Sacramento, Cal.
48. Peoria Railway Terminal Co., Peoria, Ill.
49. Puget Sound Electric Railway, Tacoma, Wash.
50. Puget Sound Traction, Light and Power Co., Seattle Division, Seattle, Wash.
51. Quincy Horse Railway and Carrying Co., Quincy, Ill.
52. Roanoke Railway and Electric Co., Roanoke, Va.
53. Rhode Island Co. (The), Providence, R. I.
54. San Diego Electric Railway Co., San Diego, Cal.
55. San Francisco-Oakland Terminal Railways, Oakland, Cal.
56. Savannah Electric Co., Savannah, Ga.
57. Shore Line Electric Railway Co., Saybrook, Conn.
58. Southern Michigan Railway Co., South Bend, Ind.
59. Syracuse, Lake Shore and Northern Railroad Co., Syracuse, N. Y.
60. Syracuse Rapid Transit Co., Syracuse, N. Y.
61. Syracuse and Suburban Railroad Co., Syracuse, N. Y.
62. Terre Haute, Indianapolis and Eastern Traction Co., Indianapolis, Ind.
63. Texarkana Gas and Electric Co., Texarkana, Ark.
64. Twin City Rapid Transit Co., Minneapolis, Minn.
65. Twin State Gas and Electric Co., Brattleboro, Vt.
66. Utica and Mohawk Valley Railway Co., Utica, N. Y.
67. Valley Traction Co., Lemoyne, Pa.
68. Washington, Baltimore and Annapolis Electric Railway Co., Baltimore, Md.

69. Washington Water Power Co. (The), Spokane, Wash.
70. Wilmington and Philadelphia Traction Co., Wilmington, Del.
71. Worcester Consolidated Street Railway Co., Worcester, Mass.
72. York Railways, York, Pa.
73. Wheeling Traction Co., Wheeling, W. Va.
74. Tacoma Railway and Power Co., Tacoma, Wash.
75. The Wilkes-Barre Railway Co., Wilkes-Barre, Pa.

COMPILATION OF DATA COLLECTED BY JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS

Data Sheet No. 90 — July 1912

Key No.	Total miles		Line operated—Miles						Minimum headway						Key No.
			City		Suburban		Interurban		City		Suburban		Interurban		
	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	
1	20	17	2	.....	.....	.....	18	17	7½ min...	.....	.....	.....	1 hr. in winter; 10 min. in summer		1
2	[1]37	14	24.5	2.6	13.0	11.40	.....	.....	4 min.[2]..	15 min.[3]..	.....	.....	.....	.....	2
3	125.59	42	33.08	2.03	.....	.....	92.51	42	15 min...	15 min...	.....	.....	30 min...	15 min...	3
4	18.7	2.83	18.7	2.83	.....	.....	.....	.....	6½ min...	.....	.....	.....	.....	.....	4
5	63.43	2.73	1.23	1.	7.27	1.73	53.2	.....	15 min...	15 min...	15 min...	15 min...	30 min...	.....	5
6	632.94	121.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
7	55.03	40.45	38.07	36.51	16.96	3.94	.....	.....	6 min....	5 min....	10 min...	6 min....	.....	.....	7
8	5.1	25.55	[4]5.1	[4]1.6	.....	.....	.....	[5]13.95	5 min....	1 min....	.....	.....	.....	[6].....	8
10	57.87	.....	.....	47.04	.....	10.83	.....	.....	.....	30 sec....	.....	3 min....	.....	.....	10
11	40.5	15.7	11.3	10.8	28.4	5.8	.....	.....	5 min....	1 min....	15 min...	2 min....	.....	.....	11
12	90	20	2	.....	.....	.....	88	20	15 min...	.....	.....	.....	35 min...	5 min....	12
13	100	21	45	15	.....	.....	59	2	7½ min...	.....	.....	.....	60 min...	.....	13
14	22	.....	12	.....	.....	.....	10	.....	15 min...	.....	.....	.....	20 min...	.....	14
15	[8]38.14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15
16	63.0	83.1	35.9	83.1	.....	.....	27.1	.....	.....	1 min....	.....	.....	10 min...	.....	16
17	[1]16.73	31.85	16.73	31.85	.....	.....	.....	.....	20 min...	1 min....	.....	.....	.....	.....	17
18	49	2	20	2	.....	.....	29	.....	10 min...	2 min....	.....	.....	30 min...	.....	18
19	25.09	3	22.09	.....	3	.....	.....	.....	7½ min...	4 min....	15 min...	.....	.....	.....	19
20	56.32	.....	4.96	.....	.....	.....	51.36	.....	.....	.....	.....	.....	.....	.....	20
21	26	.....	1	.....	.....	.....	25	.....	.....	.....	.....	.....	1 hour...	.....	21
22	34.34	22.31	16.13	1.08	2.29	.....	13.92	21.23	5 min....	5 min....	15 min...	15 min...	30 min...	30 min...	22
23	248	17	62.58	16.76	.....	.....	137.65	10.06	10 min...	5 min....	.....	.....	60 min...	.....	23
24	14	.....	5.5	.....	.....	.....	8.5	.....	10 & 20 m.	.....	.....	.....	1 hour ...	.....	24
25	48	2	.....	.....	48	2	.....	.....	.....	.....	1 hour...	1 hour...	.....	.....	25
26	434.77	2	.....	.....	.....	.....	434.77	2	.....	.....	.....	.....	50 min...	40min....	26
27	365	11	51	9	.....	.....	314	2	10 min...	3 min....	.....	3 min....	[9]30 min..	[9]30 min...	27

[1] Including short turnouts, etc. [2] Except city loop. [3] One min. during park season. [4] Surface. [5] Elevated, 8.22; subway, 5.73.
[6] Elevated, 1½ min., subway, 2 min. [8] Including 6 miles double track. [9] With occasional headway of 10 min,

COMPILATION OF DATA COLLECTED BY JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS — Continued

Key No.	Total miles		Line operated—Miles						Minimum headway						Key No.
			City		Suburban		Interurban		City		Suburban		Interurban		
	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.	
28	9.5	1	9.5	1	.....	.....	.....	.....	10 min...	10 min...	.....	.....	.....	.....	28
29	40	2	3	2	.....	.....	35	.....	30 min...	10 min...	.....	.....	45 min...	.....	29
30	25	7	7	.....	.....	.....	25	.....	5 to 20 m.	.....	.....	.....	1 hr.; Sunday 30 min.	.....	30
31	8	.....	8	.....	.....	.....	.....	.....	10 min...	.....	.....	.....	.....	.....	31
32	24.54	10.81	14.21	7.74	10.30	3.06	.....	.....	5 min....	2 min....	15 min...	10 min...	.....	.....	32
33	38	.....	10	.....	.....	.....	28	.....	10 min...	.....	.....	.....	1 hour...	.....	33
34	1.89	20.74	.....	.....	.....	.....	1.89	20.74	.....	.....	.....	.....	5 min....	5 min....	34
35	[10] 121	[11] 12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35
37	91.45	83.54	.....	74.86	4.46	8.69	87.1	.....	.....	2 min....	7½ min...	.....	15 min...	.....	37
38	.....	.....	.....	.....	.....	.....	.....	.....	12 min...	12 min...	.....	.....	.....	.....	38
39	15.95	124.69	15.95	111.73	.....	11.11	[2].....	[13].....	.....	3½ min...	.....	5 min....	.....	.....	39
40	48	1	8	1	25	.....	15	.....	15 min...	15 min...	30 min...	.....	60 min...	.....	40
41	40	10	.....	5	.....	.....	40	5	.....	15 min...	.....	.....	30 min...	30 min...	41
42	31.70	.....	.....	.....	.....	.....	31.70	.....	.....	.....	.....	.....	.....	.....	42
44	.....	.....	.....	.....	.....	.....	76.22	3.26	2 min....	23 sec....	3 min....	1½ min...	30 min...	.....	44
45	28	.....	11	.....	.....	.....	17	.....	.....	.....	.....	.....	.....	.....	45
46	5.23	.....	.....	.....	5.23	.....	.....	.....	.....	.....	30 min...	.....	.....	.....	46
47	9.63	15.16	.....	.....	.....	.....	.....	.....	10 min...	10 min...	.....	.....	.....	.....	47
48	8	2	.....	2	.....	.....	8	2	.....	20 min...	.....	.....	17.6 min.	.....	48
49	31.7	16.8	.....	6.2	.....	.....	31.7	10.6	.....	5 min....	.....	.....	10 min...	10 min...	49
50	198.91	.....	37.71	161.20	.....	.....	.....	.....	8 min....	40 sec....	.....	.....	.....	.....	50
51	18.5	4	18.5	4	.....	.....	.....	.....	15 min..	7½ min...	.....	.....	.....	.....	51
53	272.23	45.61	168.86	35.60	103.37	10.01	.....	.....	10 m[in]n...	5 min....	30 min...	15 min...	15 min...	.....	53
54	7	63	[14] 7	[14] 63	.....	.....	.....	.....	[14] 10 min..	[14] 5 min...	.....	.....	.....	.....	54
55	144.33	[15] 79.41	143.83	79.41	.....	.....	.....	.....	10 min...	45 sec....	.....	.....	.....	.....	55
56	30.53	12.96	11.80	9.81	18.73	3.15	.....	.....	10 min...	7½ min...	15 min...	7½ min...	.....	.....	56
57	50	.....	.....	.....	.....	.....	50	.....	.....	.....	.....	.....	30 min...	.....	57
58	36	3	3	1	.....	.....	.....	.....	60 min...	60 min...	.....	.....	60 min...	60 min...	58
59	14	6	.....	.....	.....	.....	14	6	.....	.....	.....	.....	15 min...	2–3½ min.	59
60	27.63	31.46	13.33	28.76	14.30	2.70	.....	.....	4 min....	4 min....	4 min....	4 min....	.....	.....	60
61	12.5	2.5	.....	2.5	.....	.....	12.5	.....	.....	30 min...	.....	.....	30 min...	.....	61
62	384.36	10.25	16.51	10.25	.....	.....	347.35	.....	15 min...	15 min...	.....	.....	1 hour...	.....	62

63	11	.5	9.5	.5	1.5	.....	.....	.....	15 min...	5 min....	.....	.....	.....	.....	63
64	57.89	[16]153.9	16.73	137.13	41.16	16.77	.....	.....	.....	20 sec....	30 min...	10 min...	.....	.....	64
65	5	.....	5	.....	.....	.....	.....	.....	½ hr.....	.....	.....	.....	.....	.....	65
66	32.61	.....	[17]23.33	15.35	[17]9.48	29.91	20	20	2 min....	2 min....	15 min...	15 min...	30 min...	30 min...	66
67	39	1	.....	.....	.....	.....	39	1	.....	.....	.....	.....	16 min...	.....	67
68	21.33	40.54	1.28	8.38	.....	.....	20.05	32.16	7 min....	1 min....	.....	.....	5 min....	5 min....	68
69	111.19	35.74	14.90	35.74	.....	.....	22	8.73	2½ min...	2½ min...	.....	.....	5 min....	5 min....	69
70	100	21	38.50	17.50	7	.....	37	.....	6 min....	3–5 min..	10–30 min.	.....	15–30 min	.....	70
71	285	43	86	43	96	6	48	4	1 hour...	1 hour...	1 hour...	1 hour...	1 hour...	1 hour...	71
72	64.54	8.76	12.51	5.46	37.17	1.97	14.86	1.33	10 min...	5 min....	1 hour...	1 hour...	1 hour...	1 hour...	72
73	87	30	.....	20	41	10	16	.....	.....	5 min....	8 min....	8 min....	30 min...	.....	73
74	46.7	21.3	24.3	21.3	22.4	.....	.....	.....	10 min...	1 min....	20 min...	.....	.....	.....	74
75	61.26	17.42	15.86	3.07	32.10	6.97	13.30	7.38	[18]2½ min..	[18]4 min....	[18]5½ min..	[18]5 min...	[18]15 min..	[18]15 min..	75

[10] 133 miles first track. [11] Second track, 12 miles. [12] Elevated, 1.7 miles; subway tunnel, .15 mile. [13] Elevated, 3½ miles; subway tunnel, 3½ miles. [14] Including suburban. [15] In addition yard tracks, etc., 17.88 miles. [16] Special track, 24.45 miles. [17] Sidings: City, 2.217 miles; suburban and interurban, 3.6 miles. [18] Each way. Included with suburban.

COMPILATION OF DATA COLLECTED BY JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS — Continued

Data Sheet No. 90 — July 1912

Key No.	Maximum speed — miles per hour						Maximum service braking distance in feet	Contact used			Propulsion current A. C. or D. C.	Voltage	Key No.
	City		Suburban		Interurban			Trolley wheel	Pantagraph	Third-rail shoe			
	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.							
1	8	.....	.....	.....	[1] 21	[1] 21	.....	Yes, in cities....	.....	Yes, on int. serv.	D. C.	550	1
2	30	30	30	30	.....	.....	150 ft. at 30 m.p.h.	Yes, 4 and 5 in ..	.....	.....	D. C.	575	2
3	25	25	.....	.....	70	70	.....	Yes, Fox River Div. & city.	.....	Yes, Third-Rail Division.	D. C.	600	3
4	25	.....	.....	.....	.....	.....	.....	Yes, 4 in. Ideal..	.....	.....	D. C.	550	4
5	8	8	8	8	12	.....	120 feet.....	Yes.....	.....	.....	D. C.	550	5
6	.....	.....	.....	.....	.....	.....	.....	Yes.....	.....	.....	D. C.	600	6
7	7.77	9.69	21.04	12.40	.....	.....	300 feet.....	.....	.....	.....	D. C.	550	7
8	8	35	.....	.....	[2].....		200 ft. surface...	Yes.....	.....	Lindall top contact.	D. C.	550	8
10	.....	20	.....	25	.....	.....	.....	Yes and plow...	.....	.....	D. C.	.....	10
11	8	8	20	20	.....	.....	.....	Yes.....	.....	.....	D. C.	600	11
12	25	.....	.....	.....	65	.....	1,200–1,500 feet.	.....	Yes.....	.....	A. C.	6,600	12
13	20	20	.....	.....	60	60	100 feet city, 500 feet interurban	Yes.....	.....	.....	D. C.	600	13
14	12	.....	.....	.....	30	.....	.....	Yes, 6-inch.....	.....	.....	D. C.	600	14
15	.....	.....	.....	.....	20	.....	200 feet.....	Hensley; V groove.	.....	.....	D. C.	550	15
16	9.7	9.7	.....	.....	17.3	.....	.....	Yes.....	.....	.....	D. C.	550	16
17	20	20	.....	.....	.....	.....	.....	Yes.....	.....	.....	D. C.	600	17
18	15	15	.....	.....	30	.....	250 to 600 feet..	Yes.....	.....	.....	D. C.	550	18
19	12	12	15	15	.....	.....	.....	Yes.....	.....	.....	D. C.	550	19
20	.....	.....	.....	.....	45	.....	600 feet.....	Yes.....	.....	.....	D. C.	600	20
21	.....	.....	.....	.....	35	.....	500 feet.....	Yes.....	.....	.....	D. C.	600	21
22	12	12	25	25	45	45	1,000 ft. approx.	V.....	.....	.....	D. C.	600	22
23	9	9	.....	.....	40	.....	.....	Yes.....	.....	.....	D. C.	600	23
24	20	.....	.....	.....	40	.....	200 feet.....	Yes.....	.....	.....	D. C.	600	24
25	40	40	.....	.....	.....	.....	.....	Yes.....	.....	.....	D. C.	600	25
26	.....	.....	.....	.....	50	40	1,000 feet.....	Yes, 6-in.....	.....	.....	D. C.	600	26
27	15	15	25	25	60	60	150 ft. city; 1,200 ft. int.	Yes.....	.....	.....	D. C.	600–650	27
28	20	20	.....	.....	.....	.....	300 feet.....	Yes.....	.....	.....	D. C.	550	28

29	25	25	.....	.....	60	.....	.....	Yes.....	.....	.....	D. C.	600	29
30	8–12	.....	.....	.....	35	.....	.....	Yes, 4-inch.....	.....	.....	D. C.	600.	30
31	15	.....	.....	.....	.....	.....	150 feet.....	Yes.....	.....	.....	D. C.	500–550	31
32	8	8	15	15	.....	.....	150–200 feet....	Yes, 4 & 5 inch Kalamazoo....	.....	.....	D. C.	600–650	32
33	15	.....	.....	.....	50	.....	1,000 ft. int.....	Yes.....	.....	.....	D. C.	600	33
34	.....	.....	.....	.....	50–60	50–60	1,200 feet.....	.....	.....	Yes.....	D. C.	650	34
35	.....	.....	.....	.....	.....	.....	.....	Yes.....	.....	.....	D. C.	550	35
37	.....	12	20	.....	45	.....	.....	Yes.....	.....	.....	D. C.	550	37
38	6–10	6–10	.....	.....	.....	.....	.....	Yes.....	.....	.....	D. C.	550	38
39	.....	9.8	.....	20	†....	†.....	75–100 feet.....	Yes.....	.....	.....	D. C.	575	39
40	10	10	20	.....	25	.....	.....	Yes.....	.....	.....	D. C.	575	40
41	.....	25	.....	.....	25	25	250–300 feet....	Yes.....	.....	.....	D. C.	550	41
42	.....	.....	.....	.....	40	.....	.....	Yes.....	.....	.....	D. C.	600–650	42
44	27	27	27	27	60	.....	800 feet.....	Yes.....	.....	.....	D. C.	575 city; 625 int.	44
45	12	.....	.....	.....	35	.....	.....	.....	.....	.....	D. C.	550–600	45
46	.....	.....	18	.....	.....	.....	100 feet.....	Yes.....	.....	.....	D. C.	550	46
47	18	18	.....	.....	.....	.....	60 feet.....	Yes, in all cases.	.....	.....	D. C.	500	47
48	.....	15	.....	.....	30	.....	.....	Yes, Kalamazoo "U."	.....	.....	D. C.	550	48
49	.....	25	.....	.....	60	60	1,500 feet.....	Yes.....	.....	Yes.....	D. C.	600	49
50	12	12	.....	.....	.....	.....	.....	Yes.....	.....	.....	D. C.	600	50
51	8	10	.....	.....	.....	.....	90 feet.....	Yes.....	.....	.....	D. C.	500	51
53	7.32	8.76	17.34	18.12	27	.....	.....	Yes, 4½ & 6 in....	.....	.....	D. C.	600	53
54	20	20	.....	.....	.....	.....	60 feet.....	Yes.....	.....	.....	D. C.	550	54
55	35	38	.....	.....	.....	.....	850 feet.....	Yes.....	Brown Diamond trolley.	.....	D. C.	575	55
56	6.66	8.5	15	20	.....	.....	.....	Yes.....	.....	.....	D. C.	550	56
57	.....	.....	.....	.....	45	.....	500 feet.....	Yes.....	.....	.....	D. C.	1,200	57
58	20	20	.....	.....	60	60	.....	Yes.....	.....	.....	D. C.	600	58
59	.....	.....	.....	.....	55	30	1,200 ft. single track; 400 double track	Yes.....	.....	.....	D. C.	550–600	59
60	8	8	14–15	14–15	.....	.....	200 ft. with good rail.	Yes.....	.....	.....	D. C.	550	60
61	.....	12	.....	.....	35	.....	.....	Yes.....	.....	.....	D. C.	550	61
62	8	9	.....	.....	60	.....	1,000 feet.....	Yes.....	.....	.....	D. C.	650	62
63	7½	.....	.....	.....	.....	.....	.....	Yes,.....	.....	.....	D. C.	550	63
64	.....	.....	50	50	.....	.....	800–900 feet....	Yes.....	.....	.....	D. C.	600	64

[1] Including stops. [2] Elevated, 40; subway, 45. † Elevated, 9.8; subway, 9.8 m. p. h.

COMPILATION OF DATA COLLECTED BY JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS — (Concluded)

Key No.	Maximum speed — miles per hour						Maximum service braking distance in feet	Contact used			Propulsion current A.C. or D.C.	Voltage	Key No.
	City		Suburban		Interurban			Trolley wheel	Pantagraph	Third-rail shoe			
	S. T.	D. T.	S. T.	D. T.	S. T.	D. T.							
65	20	.....	.....	.....	.....	.....	100 feet.....	Yes.....	.....	.....	D. C.	600	65
66	8	8	.....	.....	.....	55	200 ft. with good rail, city; 600 ft int.	Yes.....	.....	.....	D. C.	550	66
67	8	.....	.....	.....	25	.....	.....	.....	.....	.....	D. C.	600	67
68	15	15	.....	.....	55	55	1,500 feet.....	Holland.....	.....	.....	D. C.	600 city line; 1,200 int.	68
69	25	25	.....	.....	50	.....	.....	Yes.....	.....	.....	D. C.	600	69
70	9	7–9	12	.....	12–15	.....	135 feet about...	Yes.....	.....	.....	D. C.	600	70
71	20	20	25	25	35	35	150 feet about..	Yes.....	.....	.....	D. C.	600	71
72	10.17	10.20	30	30	45	45	800 feet.....	Yes, city and sub.	Yes, int.....	.....	Both.	6600 and 600	72
73	.....	9	12	.....	16	.....	.....	Yes.....	.....	.....	D. C.	600	73
74	30	30	30	.....	.....	.....	300 feet.....	Yes.....	.....	.....	D. C.	600	74
75	12	12	30	30	40	40	600 feet.....	Yes.....	.....	.....	D. C.	500–600	75

COMPILATION OF DATA COLLECTED BY THE JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS — Continued

Data Sheet No. 90 — April 24, 1912

Key No.	System of Signaling now used			Remote Control or Dispatcher's		Manual Block			Are signals in use experimental	Key No.
	Continuous track circuit	Short track circuit	Trolley contactors	Signals over telephone wires	Over separate wires	Station operators	Staff tokens	Lamps operated by crews		
1	None.....	None.....	On a section of ¾ mile in length	.....	.....	.....	.....	.....	.....	1
2	.....	.....	19 sets of three makes	.....	Stromberg-Carlson on separate wire.	None.....	None.....	None.....	Yes.....	2
3	*.....	.....	*.....	*.....	.....	.....	.....	.....	No, except one controlled by 'phone wire.	3
5	Do not use automatic signals.	.....	.....	.....	.....	.....	.....	.....	.....	5
6	.....	.....	*.....	.....	.....	.....	.....	*.....	Yes.....	6
7	.....	.....	.....	.....	.....	.....	.....	.....	No.....	7
8	*.....	.....	*.....	.....	.....	.....	.....	.....	No.....	8
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	9
10	No signals.....	.....	.....	.....	.....	.....	.....	.....	.....	10
11	.....	.....	*.....	.....	.....	.....	.....	.....	No.....	11
12	*.....	.....	.....	.....	.....	.....	.....	.....	No.....	12
13	.....	.....	.....	.....	.....	.....	.....	*.....	No.....	13
14	No automatic signals in use.	.....	None.....	None.....	None.....	None.....	None.....	None.....	.....	14
15	.....	.....	.....	.....	.....	.....	.....	*.....	No.....	15
16	None.....	We have very little single track, not enough to affect our schedules.	.....	We operate cars by separate phone system, but no signals.	.....	.....	.....	.....	.....	16

COMPILATION OF DATA COLLECTED BY JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS — Continued

Key No.	System of Signaling now used			Remote Control or Dispatcher's		Manual Block			Are signals in use experimental	Key No.
	Continuous track circuit	Trolley circuit	Short track contactors	Signals over telephone wires	Over separate wires	Station operators	Staff tokens	Lamps operated		
17	We have no automatic signal device in operation			.....	.....	.....	.....	.....	.....	17
18	.....	.....	.....	.....	.....	.....	.....	*.....	No.....	18
19	.....	.....	*.....	.....	.....	.....	.....	.....	No.....	19
20	None.....	.....	.....	None.....	None.....	None.....	None.....	.....	.....	20
21	.....	.....	*.....	.....	*.....	.....	.....	.....	Yes.....	21
22	.....	.....	.....	.....	.....	.....	.....	*.....	Yes.....	22
23	.....	.....	.....	.....	.....	.....	.....	.....	No.....	23
24	None.....	None.....	None.....	*.....	.....	None.....	.....	.....	.....	24
25	.....	.....	*.....	.....	.....	.....	.....	.....	No.....	25
26	*.....	.....	*.....	.....	*.....	.....	.....	.....	No.....	26
27	.....	.....	.....	.....	*Telegraph Signal Co., Rochester, N. Y., (Dispatcher's signals.)	*At sub-stations and ticket agencies.	.....	.....	No.....	27
28	None.....	None.....	None.....	None.....	None.....	None.....	None.....	Two blocks at special locations.	No.....	28
29	None.....	None.....	None.....	None.....	None.....	None.....	None.....	None.....	.....	29
30	None.....	.....	.....	None..... (By orders given to train men by telephone.)	.....	.....	.....	.....	.....	30
31	None.....	.....	.....	.....	.....	.....	.....	.....	.....	31
32	.....	.....	*12 U. S. One Nachod automatic.	.....	.....	.....	.....	.....	No.....	32
33	Have no signals	.....	.....	.....	.....	.....	.....	.....	.....	33

34	.....	.....	.....	.....	.....	.....	Yes.....	.....	No.....	34
35	2 sets—Gen. Ry Company.	General Ry...	11 sets Nachod.	2 lines—one 20 miles; one, 45 miles.	Yes.....	.....	.....	58 sets.....	No.....	35
37	.....	.....	*.....	.....	.....	.....	.....	.....	Yes.....	37
38	None.....	.....	.....	.....	.....	.....	.....	.....	.....	38
39	Yes, only two..	.....	.....	.....	.....	.....	.....	.....	.....	39
40	Dispatchers' telephone at all meeting points			.....	.....	.....	.....	.....	No.....	40
41	.....	.....	*.....	.....	.....	.....	.....	*.....	No.....	41
44	.....	.....	.....	.....	.....	.....	.....	.....	No.....	44
45	None.....	.....	.....	.....	.....	*.....	.....	.....	Yes.....	45
47	None.....	None.....	None.....	None.....	None.....	.....	.....	8 lamps forming 4 block systems.	No.....	47
48	Operated by telegraphic train orders.....			.....	.....	.....	.....	.....	No.....	48
49	None.....	.....	.....	.....	.....	.....	.....	.....	.....	49
50	.....	.....	.....	.....	.....	.....	.....	Yes.....	No.....	50
52	.....	.....	.....	.....	.....	.....	.....	.....	.....	52
53	.....	.....	10 blocks—3.5 miles.	43.46 miles....	.....	.....	3 blocks—8 miles (flag tokens).	193 blocks....	No.....	53
54	None.....	.....	.....	.....	.....	.....	.....	.....	.....	54
55	*(Suburban lines).	.....	*City lines....	.....	.....	.....	.....	.....	No.....	55
56	.....	.....	.....	.....	.....	.....	*.....	*.....	No.....	56
57	No form of block signals in use on any part of the road.			.....	.....	.....	.....	.....	.....	57
58	.....	.....	.....	.....	.....	.....	.....	*.....	No.....	58
59	All signals A.C. Continuous track circuit..	.....	.....	.....	.....	.....	.....	.....	No.....	59
60	.....	.....	*.....	.....	.....	.....	.....	*.....	No.....	60
61	.....	.....	.....	.....	.....	.....	.....	*.....	No.....	61
62	Installing 16 miles.	.....	.....	.....	.....	.....	.....	.....	Yes.....	62
63	None used.....	.....	.....	.....	.....	.....	.....	.....	.....	63
64	.....	.....	.....	Approx. 15 miles of single track suburban line are so equipped.	.....	.....	.....	.....	Yes.....	64

COMPILATION OF DATA COLLECTED BY JOINT COMMITTEE ON BLOCK SIGNALS FOR ELECTRIC RAILWAYS — Concluded

Key No.	System of Signaling now used			Remote Control or Dispatcher's		Manual Block			Are signals in use experimental	Key No.
	Continuous track circuit	Short track circuit	Trolley contactors	Signals over telephone wires	Over separate wires	Station operators	Staff tokens	Lamps operated by crews		
65	No system in use.	.....	.....	.....	.....	.....	.....	.....	.....	65
66	.....	.....	.....	.....	.....	.....	.....	One.....	No.....	66
67	9 block automatic.	.....	9 blocks.....	None.....	None.....	.....	.....	Trail lights...	.....	67
68	*	.....	.....	.....	.....	.....	.....	.....	Yes.....	68
69	*With automatic stop.	A. C.....	No.....	.....	Yes.....	No.....	No.....	No.....	No.....	69
70	.....	.....	.....	Ramsey light signal.	.....	.....	.....	The Ramsey lights are operated by crews.	No.....	70
71	.....	.....	*.....	*.....	.....	.....	.....	.....	.....	71
72	.....	.....	.....	Interurban ...	.....	.....	.....	*Suburban....	.....	72
73	.....	.....	*.....	.....	.....	.....	.....	Lamps.....	No.....	73
75	.....	.....	*.....	.....	.....	.....	.....	.....	No.....	75

*Indicates an affirmative answer.

NUMBER MILES SIGNALS INSTALLED DURING 1911

Key No.	Miles of road	Single track	Double track	Kind	Manufacturer	Cost per signal installed	Cost per block installed	Key No.
2	None							2
3		2.3		A track circuit permissive block with circuit controllers to determine direction of traffic	General Electric Company		$3,192 33	3
6	6.4	6.4		Automatic and Manual Block	U. S. Signal Co	$147 65* 38 71†	$295 30* 79 42	6
7			None					7
8	2.0		2.0	Trolley contactors	U. S. Electric Signal Co		$365	8
	3.1‡		3.1‡	A, C. Continuous track circuit	Union Switch and Signal Co.	$750 00	1,691 00	
12	3	3		Light signals	Union Switch & Signal Co.‡			12
13	None							13
14	None							14
16	None							16
19	½			Type "K"	U. S. Signal Co	$784 07	$784 07	19
21	None			U. S. C–1	U. S. Signal Co	100 00	300 00	21
22	1.91	1.91		Lamps operated by crew	Our own make			22
23	Short stretches of Single — City — Track							23
24		None						24
26	75.4	75.4		Semiphore Style B — Track circuit control	Union Switch & Signal Co	$900 00§	$2,600 00§	26
27	None	None	None					27
28	None							28
29	None							29
30	None							30
32	10	10			Nachod	$350 and 360	$362 and 372	32
34				None				34
35	18	18		Three-General Railway 15–Nachod				35
36	(Duplicate)							36
37		¼		Trolley contact	Nachod			37
40	None							40
41	20	12	8	Manual block	Own	$12 00	$150 00	41
42		None						42

*U. S. Signal Co, † Manual Blocks made by Bay State Street Railway Co. ‡ Subway § Approximate

NUMBER MILES SIGNALS INSTALLED DURING 1911—Continued

Key No.	Miles of road	Single track	Double track	Kind	Manufacturer	Cost per signal installed	Cost per block installed	Key No.
44	.....	.....	.....	.....	Nachod signals.....	.....	.....	44
47	2.44.....	2.44.....	.....	.....	Elect. Service Supply Co....	$22.75–$27 75	$139–$175....	47
48	None.....	.....	.....	.....	.....	.....	.....	48
52	.....	.....	.....	.....	.....	.....	.....	52
53	9.00.....	9.00.....	.....	(3.5 mi.) 10 blocks automatic	Electric Ry. Signal Company	$238.66 (automatic).....	$477.33 (automatic).....	53
				(5.5) 12 blocks — hand.....	.....	.....	$90 00 per block; hand signals.	
55	7.40.....	3.55.....	3.85.....	Combination light and Solenoid operated disc — city lines.	United States Elec. Signal Co.	$110 00.....	$450 00.....	55
				Elec. motor Semaphore AC 3 position Model 2A GRS Co. suburban lines,	Gen. Ry. Signal Co.....	300 00.....	623 00.....	
56	None.....	.....	.....	.....	.....	.....	.....	56
58	None.....	.....	.....	.....	.....	.....	.....	58
59	14.....	14.....	.....	A. C. continuous track circuit	Union Switch & Signal Co.	$1,400.00 abt. single track incl, wire, etc,	$2,800.00 (2 signals per block)	59
60	.....	16,950 ft.....	.....	(Liverpool) automatic (Green St.) hand operated	.....	.....	.....	60
64	None.....	.....	.....	.....	.....	.....	.....	64
67	.....	.....	.....	.....	Eureka Automatic Signal Co.	.....	$500 00.....	67
68	None.....	.....	.....	.....	.....	.....	.....	68
69	.....	.....	.....	A. C. automatic semaphore type GRS. 2A.	General Railway Signal Co., Rochester, N. Y.	$1,000 00....	Av. 32 blocks—$1,223 25....	69
	(Complete installation 1910...		.....					
71	30.....	30.....	.....	U. S. type G. 1 semaphore attachment.	U. S. Electric Signal Co....	225 00 abt...	450 00.....	71
72	None.....	.....	.....	.....	.....	.....	.....	72
73	8.....	8.....	.....	Automatic tookout manual operated.	Nachod Signal Co.....	$185 00.....	$365 00.....	73
75	None.....	None.....	None.....	.....	.....	.....	.....	75

NUMBER MILES SIGNALS INSTALLED DURING 1911 — Continued

Key No.	Average cost per mile track	Average length of block in feet	Number of miles contemplated installing signals, 1912	Kind to be installed	Do you approve permissive signalling	Use of block signals aided or retarded train movement	Key No.
1	.....	.....	.....	.....	.....	.....	1
2	.....	.....	None.....	.....	Question too broad to answer briefly.	Under our conditions has aided very materially. Practically all single track sections, except fixed meeting points, controlled by automatic signals.	2
3	$1,387 97	.....	One and possibly 19 of double track.	A. C. track circuit spacing signals.	No; except on each section of track where two different lines operate.	Aided as well as safeguarded.....	3
6	*369 12 †148 30	*4,220 ..... †2,840.	.....	.....	.....	.....	6
7	.....	.....	.....	.....	Yes.....	Aided.....	7
8	.....	781 double..... 1,923 single.	0.25.....	U. S. signal (electric).	Not for our conditions.	Aided by increasing number of trains which can be run with safety.	8
	‡7,610 00	‡1,500.....	‡1.0.....	A. C. single rail return type.			
11	.....	.....	.....	.....	Yes.....	We think it has aided the movement of cars and trains.	11
12	.....	About 1½ miles....	None.....	.....	Don't think much of it.	.....	12
13	.....	.....	None.....	.....	Yes.....	No experience.....	13
14	.....	.....	None.....	.....	.....	.....	14
15	.....	.....	.....	.....	Yes; when governed by train order.	Aided.....	15
16	.....	.....	None.....	.....	.....	.....	16
18	.....	.....	.....	.....	.....	Aided.....	18
19	.....	2,640.....	None.....	.....	No.....	Aided.....	19
21	150 00	12,000.....	None.....	.....	No.....	.....	21
22	.....	.....	None.....	.....	Yes.....	Aided.....	22
23	.....	.....	.....	.....	For slow operation, yes.	Aided.....	23
24	.....	.....	0.75.....	Automatic block...	Yes.....	No experience, but anticipate that it will expedite movement under our conditions.	24

* United States Signal Company. † Bay State Street Railway Co. ‡ Subway.

NUMBER MILES SIGNALS INSTALLED DURING 1911 — Concluded

Key No.	Average cost per mile track	Average length of block in feet	Number of miles contemplated installing signals, 1912	Kind to be installed	Do you approve permissive signalling	Use of block signals aided or retarded train movement	Key No.
26	$1,800 00	10,500	11	Semaphore, style B, track circuit control.	Not on single track.	Aided	26
27	.....	.....	18	Automatic continuous track circuit.	Yes	Aided, if dispatchers' signals are working properly. If not, retarded.	27
28	.....	.....	None	.....	We make use of signals compulsory.	Aided very much	28
29	.....	.....	None	.....	No	No experience	29
30	.....	.....	Don't know	Have not decided.	.....	Will be of great benefit and aid if a good signal can be had. Am waiting for a perfect working signal to come out.	30
31	.....	.....	None	.....	.....	.....	31
32	471 80	.....	3	Nachod automatic.	Yes	Aided	32
34	.....	.....	None	.....	No	.....	34
35	.....	Nachod ½, Gen. Ry. 1¼ miles.	37	General railway	No	Aided	35
37	.....	¼ mile	.....	.....	Yes	.....	37
40	.....	.....	None	.....	.....	.....	40
41	80 00	10,000	4	Manual block	.....	Aided	41
42	.....	.....	None	.....	.....	Have no block signals	42
46	.....	.....	None	.....	.....	.....	46
47	118 80	3,475	None	.....	.....	Aided	47
50	.....	.....	.....	.....	No	.....	50
53	†1,363 80	1,848	.....	.....	.....	Aided	53
55	*873 00 ‡6,077 00	500 (Suburban).	5.46	.....	Yes; so far as our traffic conditions are concerned.	Aided. Key Route Pier most densely signaled piece of track in the world — 3 miles D. T. — 76 signal locations (3 per upper guard A. C.).	55
				Elec. motor, semaphore A. C. (1.58 miles) & combination light and solenoid operated disc. (3.88 miles).			

56	.....	.....	.....	.....	No.....	Aided materially.....	56
58	.....	.....	None.....	.....	Yes.....	No experience.....	58
59	1,000 00	1,500.....	None.....	.....	No.....	Generally speaking, signals are only to regulate movements, but on double track, aid in movement of traffic by permitting closer headway with greater safety.	59
60	.....	.....	.....	.....	.....	Aided.....	60
61	.....	.....	.....	.....	.....	Has retarded, but consider this as more than overbalanced by the factor of safety.	61
62	.....	.....	16.....	Gen. Ry. Signal Co. Continuous circuit.	Yes; for following trains.	.....	62
64	.....	.....	None.....	.....	.....	.....	64
65	.....	.....	None.....	.....	.....	Both results have been observed.....	65
66	.....	.....	.....	.....	.....	Aided.....	66
68	.....	.....	14.....	Undecided.....	Conditions would govern.	No block signals on this property as yet.....	68
69	1,779 30	.....	None.....	.....	No.....	Aided, and has increased the efficiency of operating crews to practically 100 per cent. All signals equipped with automatic stop brake attachment. All motor cars equipped with Willson-Wright automatic train arrester.	69
70	.....	.....	.....	.....	.....	Yes; our signals do aid, in fact do not think we could operate without them now.	70
71	225 00	2,700.....	.....	V. S. type G; 1 semaphore attachment.	.....	Aided.....	71
73	.....	4,000.....	36.....	20 miles with Nachod, 16 miles U. S.	.....	Aided.....	73
75	.....	.....	12.....	Nachod.....	Yes.....	Aided.....	75

* United States Electric Co. signals. † For Electric Railway Signal Co. ‡ General Railway Signal Co. signals.

Discussion of the Report of the Committee on Block Signals for Electric Railways

MR. WALDRON:—The five recommendations on page 207 are set forth for the consideration of next year's Committee. I will say, in connection with our report, under the heading of "Digest of Block Signal Laws and Rulings" it is said that the State of Wisconsin has no laws bearing on this subject, but it appears that the reply to Mr. Conn's letter concerning this was not thoroughly understood; and there should have been included in this Digest of Block Signal Laws and Rulings, the following ruling of the Railroad Commission of the State of Wisconsin:

> Safety devices; block signals; Sec. 1797-a. It shall be the duty of every railroad to adopt reasonably adequate safety measures and install, co-operate and maintain reasonably adequate safety devices for the protection of life and property. If, after investigation, the Commission shall determine that public safety requires the installation, operation and maintenance of a block system or other safety device or measure by any railroad, the Commission may, after notice and hearing as provided in Section 1797-12, order such railroad to install, operate, and maintain a block system or other safety device or measure as may be necessary to render the operation of such railroad reasonably safe. (Ch. 297, 1911.)
>
> The word "railroad" as used in this law applies to all classes of roads whether using steam or electric power, and, therefore, Wisconsin does have a law which gives its Railroad Commission authority to investigate the conditions on any road, and while no action has as yet been taken by the Commission relative to interurban lines, it is possible that some action will be taken in the near future.

Your Committee would like the representatives of member companies to enter into this discussion.

MR. NICHOLL:—I cannot say that I am very familiar with block signal operation. We have recently installed, however, on our lines nine blocks of a type fully described in this report, and manufactured by the General Railway Signal Company. We have had them in operation for the last ten days only, but during that time they have worked splendidly, I believe only two failures having occurred. These failures were of a nature that could hardly be avoided for new installation. We find that our men take very nicely to the use

of the block signaling system. They did not have a great deal of instruction on the subject, but the operation of the system seemed to be so simple that they all learned it very quickly and well. We were unable to find any book of rules which exactly filled the condition of these signals, but in conjunction with representatives of the signal company we formulated our own rules. These rules were given to the men just a few days in advance of the placing of the signals in effect. We had an instruction car, which was accompanied by our signal maintainer and an engineer of the signal company and we took all of our men over the road only two or three times and instructed them in the use of the signals and they seemed to be very apt and learned very readily. We have not had the signals in operation long enough to know exactly whether or not they will increase the capacity of the track, but hope that they will, as we have been told by people operating block signals that they will increase the capacity of the track probably 25 per cent. At this time we cannot say that we know very much about that, however, I believe that the operation of extra trains is a little more difficult than it was without the signals. It possibly delays the extra trains a little on account of having to keep the immediate block in advance clear for the approaching or scheduled train.

MR. JEFFRIES:— Our signals and those of the Union Traction Company of Indiana, were both installed by the General Railway Signal Company, and are of the same type, excepting that those of the Union Traction Company are arranged for operation in connection with double-end sidings; whereas ours are for stub-end sidings. Our signals were put in operation on August 19th, and have, therefore, been in use a little longer than those of the Union Traction Company. Our records show that from August 21st, to October 2nd, inclusive, there were 25,198 operations of these signals, and out of this number there were but eleven failures. However, four of these failures were due to the signal engineers working on the apparatus, and not due to the signals. Two of the other failures were due to poor adjustments in the switch box, one broken cross-bond, one bad contact relay, one switch instru-

ment open, one ground on the line, and one for causes unknown. Therefore, there were only seven failures in over 25,000 operations. We believe that with a new installation such as this is, that we will have a better record in the future. The section of track that is blocked is about sixteen miles, consisting of seven curves and six blocks; a very crooked piece of track where cars are operated at high speed, in some places coming down grade at from 65 to 70 miles an hour. It is an exceedingly good location to test out these signals. The operation seems to be similar and the rules that we have adopted are the same as on the line operated by Mr. Nicholl. The men all take to the system readily, and we regard this piece of track as being much safer than before the signals were put in. Experience shows that the lights can be seen about 2,000 feet in broad daylight, with the sun shining. As far as we have gone we are very well satisfied with this block system.

Mr. Henry:— On the question of block signaling, Indiana has had a little experience in getting ready for block signals; as to the use of them our experience is short. I want to stop at this time, if you will allow me, to say a few words about the action of our Railroad Commission and their electrical expert, Mr. Hovey, in connection with this proposition, for the reason that I want to compliment them, and for the additional reason that I think the suggestions I have to make may be worth something to some of you who are now where we were two years ago. Two years ago this fall there had been a number of very bad accidents in the State and the Governor called a conference of representatives of the various interurban companies with the Railroad Commission. As a result of that conference the Governor indicated, and the Commission approved of it, that the interurban companies should seek out such devices in the way of signaling as would meet their needs and yet be within their means. The legislative session following closely, the Railroad Commission asked the passage of a law which would absolutely require the installation of automatic block signals, both for steam and interurban railroads. The interurban roads, carrying out the

suggestions made in the Governor's conference, insisted upon an amendment to that bill as it was presented, so as to permit the installation of other than automatic block signals. The bill was amended and the law passed, and you will find it in the report of your Committee, now under consideration, on page 203. So that while in the first instance it required an automatic block signal, it has the further provision that the Railroad Commission may, in its judgment, approve any other kind of block signal, or any other signaling system which would reasonably tend to safety in the operation of the road. That law was passed one year ago last January and required that all the roads should be equipped by the first of January, 1912.

Immediately after the conference with the Governor, which I have referred to, the traction people of the State appointed a committee to take up, discuss, examine and report upon the question of block signaling. The Railroad Commission gave to this committee the assistance of Mr. Hovey, its electrical expert. He acted with the committee all the way through, and they took plenty of time at it, because they found this situation. So far as the Indiana interurban roads were concerned, they absolutely could not afford, financially, to install any block signal system then to be had. About $2,300 to $2,500 a mile was absolutely prohibitive. Mr. Hovey worked very industriously on the matter with this committee and finally they brought in a report to the Commission showing that some of the signal companies had agreed to put in some sections of signals for inspection. These have since been put in on the Terre Haute, Indianapolis and Eastern Traction Co., and on the Union Traction Company of Indiana, as referred to by Mr. Jeffries and Mr. Nicholl, at a very much reduced cost from the price which had been named, doing away with the use of semaphores, and using lights instead.

About this time Mr. Simmen, the inventor of the Simmen signal and train dispatching system, had been seeking to make an arrangement with our company for the installation of an experimental section of his signal, and with the approval of Mr. Hovey we made a contract with Mr.

Simmen and his associates to put in a section of 18 miles of the Simmen signal system on our line. Both these matters came up before the Committee at the same time. The contract we made with Mr. Simmen and his associates was, that his system should be subject to the approval of the Railroad Commission. They were very anxious to try out the system on a high speed line and one that was the most difficult in the State, and they felt if it would operate on a single phase line it would operate on anything. The three contracts came up about the same time, and were made with the consent and approval of the Railroad Commission. We put our installation in first. After it had been in use about three months we appeared before the Railroad Commission with Mr. Hovey, and the Railroad Commission, under the authority given by the statute, approved the Simmen Signal System for our line, and since then the other systems have been approved on the Union Traction Company of Indiana and the Terre Haute, Indianapolis and Eastern Traction Co.

What I want to call your attention to especially is this: Two years ago this question was first taken up in Indiana actively by the conference with the Governor, and over eighteen months ago the legislature passed this drastic law, and the time fixed for the absolute and unqualified installation of all the lines was the first day of January last, and yet we have had three men occupying the public position of railroad commissioners of Indiana and an electrical expert advising them, who were level-headed enough and had enough common sense, to act with us and try to work out the proposition in a living way. I commend their action to you and ask you to see if you cannot do as well with any railroad commission or public utilities commission you have to deal with on the same subject.

The Union Traction Company of Indiana and the Terre Haute, Indianapolis and Eastern Traction Co. have been able to get their installations at practically one-half the cost that they were asked two years ago, and the Simmen signal system which we have installed is a little cheaper than that; so that we feel while we have not gained all that we ought, we have made substantial progress.

Begging your pardon for going outside of the report, I want to say a few things about it. I take it that this report means really recommendations regarding a continuous track circuit automatic block. I do not understand that they mean to exclude any investigation or trying out and experimenting with anything else, although the report on the face of it would seem to indicate that. If it does I can not agree with the report; but assuming it means what I think, I do agree with it. I think this Association ought to be congratulated upon the careful work of the Committee on this question.

I suppose, Mr. President, one reason you called on me was to know something about the signal we are installing. I will tell you a little about it. The Simmen signal system is not an automatic block system, but is a system that is controlled from the dispatcher's office. The dispatcher, at his desk, controls signals which the trainmen get. It is done in this way. The dispatcher sits at a desk with keys before him that connect him with a section of third-rail at every passing siding and the cars are equipped with shoes that come in contact with these third-rails at the sidings. We installed them, one at the siding and one 2,000 feet on either side, so that the motorman would get the warning to stop or the go ahead signal 2,000 feet before he reached the siding, which with us is about as short as we can count on stopping, because we run fast schedules on our road. If the dispatcher wants to give the motorman a green light in his cab, he simply turns the switch so that he energizes the third-rail, and when the shoe on the car strikes the third-rail, it completes a circuit in the car, giving him a green light, which is held by a storage battery circuit operated by a relay actuated by the original circuit from the energized third-rail. If, on the contrary, the dispatcher wishes to give the motorman a red light he turns the switch in such manner that it does not energize the third-rail, and now when the shoe strikes the third-rail, it simply cuts in a circuit through the red light with the storage battery, and the motorman has a red light right before his eyes. That is all there is of it at that end.

In addition, there is in the dispatcher's office, a sheet, illustrated in the report on page 262, which is moved by clockwork.

It is divided into time spaces. The clock ticks, and every five seconds the sheet moves, and the needles which are just above the sheet record the exact time that the car passes over the third-rail at any speed. First, there is the first distant rail; second, the home rail; and, third, the far distant rail, so that the dispatcher has before him an absolutely exact record of the time the car passes over each one of the three rails. In addition to this, impelled by the storage battery, another set of needles start up and make a continuous indication which shows the exact movement of the trains and shows how they are all being operated. So that, in addition to the signaling proposition the dispatcher has an absolute record before him of where every train is.

There are some things as we use it, that appeal to us about this system, and the principal one is the fact that the dispatcher knows exactly where the trains are, just what they are doing, and he can arrange meeting points without bringing his trains to a stop. It is believed by those who have looked into it that we will greatly save in operation and can operate more trains than under the old system, in fact, I may say that when we were before the Railroad Commission, after the matter was settled, I said, "Gentlemen, there is one thing I have not mentioned in connection with this matter, and that is, I believe we can operate at least 10 per cent. more trains with the use of this system than we can under the present system." Mr. Hovey, the electrical expert of the Commission said at once, "You will operate 25 per cent. more trains," and I would not be surprised if he was correct.

Another great advantage is that it informs the dispatcher exactly what his trainmen are doing, and where they are, and that is a feature which appeals to us very strongly.

Another thing which appeals to us is the simplicity of the system. There is nothing in the dispatcher's office except what I have described and a simple relay, to keep in order. On the car there is nothing but a relay, the wiring, the storage battery and the lamps. There is nothing between the dispatcher's office and the car except the common wiring and the third-rail to keep in order, except one thing which I am going to describe

to you further. From what I have said you will see that it does not require any experts out on the line to keep the system in order and its simplicity is the thing that appeals to us.

We have in connection with the signal system an open-switch protector, which is a very good and at the same time a very ingenious affair. It is a common switch protector box, as used by all signaling companies, but it is so arranged that the current over the wire passes through this box, and then to the third-rail, and if the switch is left open the motorman cannot get a green light, because the line is broken by the open switch, but if the switch is closed and the line is perfect the motorman can get a green light, so that even had the dispatcher intended to give the motorman a green light, if the switch is left open, he cannot get it. In fact, a trainman leaving a switch open cannot get more than 2000 ft. away without finding it out and the approaching car is warned 2000 ft. in advance.

One of the great troubles with regard to the proper application of signaling devices is that we are compelled to do things on too small an income. We know that, and have learned it to our sorrow. The great difficulty about the whole signaling business is — we do not want to condemn it, we want everything that tends to safety, that we must have care in these things. We expect to go ahead and develop these matters as offered by the different systems, and we expect everyone interested in the subject will help to secure the best results from all of the systems. I appeal to you, and to all these people who are telling you how to do things, that you labor with them, and see if it is not possible for them to do as well by you as ours have done by us.

MR. WALDRON:— Do I understand you to say you do not approve of recommendation No. 5?

MR. HENRY:— I do not refer to any recommendation by number.

MR. WALDRON:— I understood that you wanted to call attention to the continuous track circuits, particularly, that the amount of money to be expended be directed toward the installation of the continuous track circuit control rather than upon a more expensive indication.

MR. HENRY:— I said I did not approve of the recommendation if you meant to exclude other means of signaling than block signaling. I do not mean to criticise what you say regarding block signaling or continuous track system signaling. What the Committee should do, is to recommend that which in its judgment, is the best which they could get and the safest. I have no doubt that is what the Committee is seeking to do.

MR. WALDRON:—As you said, the expenses of installation have been going down decidedly, and the price is now coming within reach of the roads.

MR. HENRY:— I did not expect to go into any discussion of the respective merits of the various systems, and I will not now, but I want to say, that I am thoroughly convinced from the investigation I have made and the experience I have had in these matters, that for interurban purposes the continuous track circuit automatic block signal is not the thing which you want. We have not had any conflict on these matters in our State, and we are not going to have any. We are going to hunt for the things we think are the best. It is just as possible to obtain with the Simmen signal system all the advantages which the continuous rail automatic block affords as it is with the continuous rail automatic block, and the reason why I say I do not think the continuous rail automatic block is the best is because it stops there. Admit, as I believe is correct, that it works perfectly — admit that — but when you have your block shut up that is all you have. No man connected with your road, except your motorman and conductor of the car, knows anything about what they are doing, where they are, or what the cause of the delay is. The system is perfect, but like a great many other perfect things it stops there — it does not do anything else.

In our system what we have in addition to that is an absolute indication on the dispatcher's desk of just what is going on at that place. The application of our system is practically limitless, and the system gives us accurate information of everything which is transpiring out on the road. In the case of the continuous rail, if Mr. Nicholl has a broken bond, it will stop the car, the same as anything else might do, but they

do not know what has stopped the car or the reason for the delay, until they investigate and discover it. That is the system — it is a perfect system, but it stops short of giving to the operating force any knowledge of what is transpiring out on the road. That is what we like about our system — we know what is going on, and if you will allow me, I want to say that, after all, I have great confidence in man, and I like to have somebody on the road who is charged with the responsibility of directing what is taking place. Automatic systems of all kinds have their places, but they do not think, and you cannot make them think — they look as if they do think sometimes, but then they are like some men, who look as if they are thinking, but really are not. That is what appeals to me — I have great confidence in the human element, and you charge the dispatcher with the responsibility of directing the operation of the road and I have confidence that we will obtain better service out of him. He knows if a man runs ahead of time, or if he loafs on the siding when he ought not to, just how long he is there and all about him. It is one of the greatest features of our system and it is the greatest aid to securing proper disclipine in the force that we have ever found.

This is no criticism of automatic blocks, you understand — I do not want to be drawn into that — they are perfect. The Committee cannot make a stronger recommendation than that. They are perfect, but the automatic blocking system only does so much and no more.

Now as to whether recommendation No. 5 is correct. I object to it, as the question is put by the chairman of the Committee, for the reason that it is no longer the proper practice for interurban roads.

Mr. Hegarty:— On page 210 it says: "On four installations of light signals the electric arc headlights located just above the floor level of cars are found to have no effect on the distinctness of the indication." Arc headlights if they strike the red signal at night, have such an effect on the signal that it does not show red, it shows almost white, and the Interstate Commerce Commission has taken up the subject of

arc headlights and has made a voluminous report on the subject. I suggest that the Committee get a copy of the report and study it. There have been several accidents throughout the country on railroads where arc headlights were used, and upon investigating these accidents it was found that the rays from the arc headlight, in striking the red signal, especially if the signal light was out, had caused the signal to show white. The Commission is now engaged in a lengthy investigation of this subject of arc headlights.

MR. NICHOLL:—With reference to the arc headlight causing a wrong signal to be shown, or changing the color of the red signal, I will say that we operate most of our headlights from the hood of the car which is 6 or 8 feet higher than the location of the light on the dashboard as used on most electric railroads. We find that it does not interfere with the motorman getting the proper signal, or rightly interpreting it, and we find that where the arc strikes the red aspect, that it shows red just faintly, so that if it is supposed to be a green or yellow signal, it would not interfere with the motorman interpreting the correctness of the signal. We do not find that it shows white.

MR. WALDRON:—Did Mr. Hegarty say that the red indication showed white?

MR. HEGARTY:— It does not show exactly white; it is more a dull orange.

MR. WALDRON:—Would not that be safe? White is not used to any extent as a clear indication. A white light displayed where a red light is normally displayed means stop.

MR. HEGARTY:— In the code of signals red means stop. When one of the accidents I referred to occurred, there was a very thorough investigation into the subject as to the effect of arc headlights on red signals, and as a result of the investigation some of the railroads discontinued the use of arc headlights. On our road, when we come to a block signal, we have the men put out the arc headlight so that they can tell what the signal means.

WRITTEN DISCUSSION BY MR. JOHN LEISENRING

It has appeared to the writer that when considering the distances at which light signals can be seen some more definite comparison between light signals and semaphores has been needed than has heretofore been given. The fact that a light signal can be seen 1000 ft., 1200 ft. or 1500 ft. means little as an actual comparison between the light and the semaphore signal on electric railroads. The writer believes that with the simple statement that a light signal of a certain type can be seen 1200 ft. this type of signal suffers as a consequence, for, as is only natural, the mind at once reverts to the well-known semaphore on steam railroads that can be seen on a clear day for possibly a mile. The physical conditions, however, surrounding the semaphore signal on the average electric line reduce the distances at which this type of signal is visible.

The writer has made some tests recently, comparing the light with the semaphore signal under the same conditions, with results as follows:

A standard semaphore signal, as adopted by the company with which the writer is connected, indicating in the upper left-hand quadrant, was placed on a long tangent running almost directly east and west. A light signal with 5-in. lenses, two 24-watt tungsten lamps behind each lens, with a 30-in. straight hood and a collar of about 10 in. for forming a background, was located near the semaphore, the green lens being above the red. The background was of the ordinary type encountered on interurban railways, trees being the main formation of the one in question. The poles on the side of the track on which the signals were placed are 8 ft. from the center line of the track. Construction is mast-arm, and the trolley is 18 ft. 6 in. from the top of the rail.

At 7:05 a. m. on the morning of Oct. 5, a bright clear morning with a slight haze near the ground, looking directly into the sun, it being slightly off to the right-hand side, the side of the pole toward the observer being in the shadow, the limit of sight of the green light in the signal above described was 2050 ft. and the limit of sight of the red was 1850 ft. The whole front of the signal was entirely in the shadow. This seems to disprove the idea that the green indication is the hardest to see under all conditions.

The semaphore signal, under the same conditions of light as stated above, could be seen in the 'stop' position, horizontal, distinctly 1500 ft.; in the 60 deg. position, which is 'proceed' on the road in question, it was clearly discernible 840 ft.; in the 90 deg., vertical position, which would be the 'proceed' indication in three-position signaling, it was clearly discernible 750 ft.

At 10:30 a. m. with the sun high and short shadows almost at right angles to the track, the side of poles toward the observer being still in the shadow, the limit of sight of the green light in the light signal was 2000 ft.; the limit of sight of the red indication was 1700 ft.

The semaphore signal was clearly discernible in the horizontal position, under same light conditions as above, about 2500 ft.; in the 60 deg. ' proceed ' position about 1500 ft., and in the 90 deg. ' proceed ' position about 1450 ft.

At 3:30 p. m., with the sun shining directly into signal at slight angle, both lenses being in the shadow, the sides of the poles toward the observer being in the sunlight, the limit of sight of the green indication was 1650 ft. and the limit of sight of the red indication was 1122 ft. The direct sun's rays were on the front of the signal, just to the edge of the red, or lower, lens.

The semaphore signal under similar conditions in the horizontal position could be seen for 3645 ft.; in the 60 deg. position for 2500 ft., and in the 90 deg. position for about 2000 ft.

At 5 p. m., when the sun was beginning to weaken and when its rays were directly on the lenses of the light signal, the green indication was discernible for 3000 ft. and the red indication for 1350 ft. The semaphore signal was practically the same as stated in the last previous observation.

The writer has confined himself entirely to limit of sight and has not considered the point of arrestive indication, as to his mind this varies largely according to the ideas of the observer. It appears to the writer that the actual distance in which a larger type of light signal can be seen does not vary greatly from those given above for the small signal. A larger signal, with more light behind it, will, however, give a more pronounced or arrestive indication after coming within the sighting distance.

It is not the idea of writer to disprove the general idea that the semaphore signal is the best all-around signal for all classes of work, for this is his firm conviction, but simply to show that with even a small light signal adequate indication can be given for average speeds as the temporary arrangement, or for use as distant signals, in this way allowing a road to secure track-circuit control at the beginning and perfect the signal indications later.

Mr. Henry:—In our section of the country we have done away with white for safety, and use green. Under our rules

of operation, if you saw white it would mean the same as red. I would ask Mr. Hovey, if he is in the room, if it is not a fact, from his knowledge of these investigations that on systems such as the Union Traction Company of Indiana, if there is not less reflection from the lights of that signal system than there is in the ordinary light on the semaphore system.

MR. HOVEY:—There is a possibility with the semaphore signals of getting a false indication. We have just completed some tests with the electric headlight and we find that if the signal lamp is not burning there is a possibility of receiving a dim reflection. It is very easy to tell, however, if the light is properly displayed. If the signal lamp is properly burning it cannot give this false indication, as it only occurs when the signal lamp goes out. If an engineer is careful he can tell that the light is improperly displayed, the reflection being very dim. With the semaphore signal, in nearly every case it is possible to see the position of the arms. In the case of high candle power signal lamps you will not have the same trouble, particularly on interurban roads, because the candle power of the light is so high; trouble from reflection only occurs when the low candle power signal lamps are used.

MR. PALMER:—I had hoped that in the report of the Committee this year there would be some definite recommendations on the first topic which was referred to them for study, namely, "For signaling single-track suburban railways for headway between 5 and 30 minutes and speed not exceeding 20 miles per hour." I have not been able to find, so far as I have examined the report, any recommendation, except that the Committee be instructed to continue the study of that topic. There are a good many of us who are operating systems where the question of control by track circuits is impossible. We have to use some kind of a signal which will be controlled by means of overhead wires. Our single track blocks need protection and they have to be protected in some manner by means of a signal operated in the way I indicate. I hoped there would be some recommendation as to standard methods of signal aspects, to which the different signal manu-

facturing companies might bring all their apparatus in harmony. As it is now, one company puts a signal system on the market that shows one aspect for " Proceed," and another one an entirely different aspect. The chairman reminds me of the cuts which are shown at the top of page 206, but that does not seem to answer my question. Where more than one car is operated on the same schedule, that is, one or more cars following the leading car, every car which enters the block after the leading car should have some indication on the signal to show that the car operates the signal and that the car is registered accurately. One of our prominent systems uses for the " Proceed " indication the upright position of the semaphore, and another system uses the 45 deg. angle position of the semaphore. What we would like to have seen is some recommendation for standard aspects for three-position signaling to be used in a somewhat different manner from what the aspects shown are intended to be used.

The discussion further brings out here the two different methods of train control, one by means of a dispatcher at headquarters handling trains, which is a system by itself and has its own uses, and the other is a system of handling the trains by means of signals automatically operated.

Mr. Waldron :— In reference to the Standard aspects it was the intention of the Committee to get aspects which would suit our conditions, not particularly confined to interurban traffic, but for use on lines in cities and towns where track circuits cannot be used but where some method of contact indication must be used to operate the signal. I think you will find with the aspects herein shown that you can work any system which is now in operation.

As for the other question brought up, about the recommendation for single track operation, the Committee did study that carefully, but felt they had not gone far enough to warrant any recommendation at this time. The Committee wanted further views from the member companies in this discussion to-day, and particularly they were anxious to find out the opinion in regard to the aspects.

Mr. Hoge :—The company that I have the pleasure of representing has been for the past year and a half building an

automatic signal that is controlled by a trolley contactor, operated along somewhat different lines than those described in the discussion here this morning, therefore I think possibly a word in passing would not be out of place. We have a contactor that is entirely different, so far as I know, from any other on the market; our contactor is operated by the spring tension of the trolley pole, raising up the contactor on the wire about 1½ inches or a little less, with no obstruction for the wheel to come into contact with. It makes no difference whether the current is on or off the line at the time the trolley passes under the contactor, it immediately shows the condition of the car when the power comes back on the line.

We developed it with a view of meeting the low price that the interurban trolley roads seem to agree is necessary in order to enable them to install signals to meet the requirements of the high speed operations of their cars with a dependable safety system. We have developed one that will operate at a speed as high as 60 to 80 miles an hour. We have that system developed and in actual operation both for spacing signals and interlocking block signals, meeting all the Signal Association requirements of the upper left hand quadrant signal, displaying both semaphore arm and lights at all times. Our block signals are positively interlocking and count any number of cars into and out of the block, and all operated by the same current as that used for the operation of the line without the expense of insulating the track. I think that is a feature which has not been touched on in the report and should be made a part of the record.

PRESIDENT ACKERMAN:—Our time for the consideration of this report is about exhausted. What will you do with the recommendations of the Committee? You will find them at the bottom of page 205 of the report and following.

MR. PALMER:—In view of what the chairman of the Committee has stated with regard to the signal aspects, I should like to inquire if my interpretation of these three-position aspects is correct for use with overhead wires.

MR. WALDRON:—Will you note what the Committee says on that point? Does not that refer to what you have in

mind? If the block is already occupied, the car will stop at the signal. If a counting device is used all cars entering the block in the same direction after the first one will do so under a caution signal.

MR. PALMER:—That angular position does not mean that the block is clear?

MR. WALDRON:— It means just what it says in the report.

MR. PALMER:—Then I do not see how these aspects could be harmonious with those of any three-position semaphore which would indicate a clear block to a car approaching. When a car approaches a signal, and before it actuates the signal, the semaphore blade has got to be in some position, either showing the block is clear, or that the block is occupied.

MR. WALDRON:—Immediately above "Proceed-with-caution" it shows the clear block. Under "Proceed-with-caution," means are provided for taking care of the second car, at those points you have spoken of.

MR. PALMER:— Let me ask you, under this interpretation of this rule, what would be the position of the semaphore blade before the signal has been actuated by the car approaching?

MR. WALDRON:—If cars were operating in both directions on the same track, it would be clear.

MR. PALMER:— Let us suppose that on a single track line the block is perfectly clear, and no car on it, and a car is approaching a signal, and wishes to proceed into the block. Now, before that car actuates the overhead contact what should be the position of the semaphore blade?

MR. WALDRON:—That would be danger.

MR. PALMER:— Under our system the block is clear.

MR. WALDRON:—It cannot be clear from both directions.

MR. PALMER:—If there is no car on the block the track would be clear. You can make it that way.

PRESIDENT ACKERMAN:—We will entertain motions to dispose of the recommendations separately. The first recommendation appears on page 205.

MR. W. H. COLLINS:— I move that the first recommendation be adopted. (Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:—We will now consider the second recommendation.

MR. RICHEY:—Does that recommendation mean that the Committee does not recommend the light indications? Does it mean they recommend semaphore indications exclusively?

MR. WALDRON:—The Committee has shown a light indication as well as a semaphore indication. They want to make it as general as possible and to suit all conditions.

MR. RICHEY:—I see that is provided in the drawings, but the Committee recommends as Standard practice "Semaphore Signals indicating in three positions in the upper left hand quadrant." Are you recommending that we adopt as standard the use of semaphore signals?

MR. WALDRON:—The Committee realizes, and everybody else realizes, that a semaphore signal is the best indication to give. Next to that comes the light signal which is cheaper than the semaphore.

The Committee is anxious to have the railroads use some good, reliable indication, whether semaphore or light, but the Committee could not well recommend what is not the best.

MR. RICHEY:—That is what I want to understand; whether in adopting this recommendation we adopt semaphore signals as the Standard of this Association; which is putting the thing pretty strong when you realize that in some cases the light indications are the best.

MR. HENRY:—Mr. Chairman, I think we might just as well get to Armageddon. I think this report ought not to have any wording which seems to tie this Association down to a continuous track circuit for automatic signals. I think it entirely proper that all of these recommendations, with very little change, be adopted; but that they should be so worded as to show that they mean, "when automatic continuous track circuit signals are used."

In the recommendation which Mr. Richey refers to, I think these words ought to be put in: "Your Committee recommends as 'Standard' practice," in the use of semaphores the following ————. That is, I think it should say that it recommends this use of semaphores when we are using them.

Therefore, I move to amend by inserting, after the word "practice" the words "in the use of semaphores."

PRESIDENT ACKERMAN:—There is no motion before the house. I called for a motion to take up the second recommendation, but as yet no motion has been made.

(Mr. Shannahan, President of the Transportation and Traffic Association, now in the Chair.)

MR. HENRY:— Now, the question I want to ask the Committee is, does it intend to limit the second and the third recommendations to semaphores?

MR. WALDRON:—The second recommendation does limit to semaphore signals, but the third does not.

MR. HENRY:—You intend by this illustration to take care of the lights?

MR. WALDRON:—Yes, sir.

MR. HENRY:—You intend recommendation No. 3 to take care of lights and semaphores?

MR. WALDRON:—That is it exactly. The Committee recommends the best way to consider semaphores but we realize that we must have lights, and we provide for them.

PRESIDENT SHANNAHAN:— To bring this question properly before the house will not some gentleman move to adopt this recommendation?

MR. W. H. COLLINS:— I move that recommendation No. 2 of the Committee be adopted. (The motion is seconded.)

MR. HENRY:—I move that recommendation No. 2 be amended so as to read this way: "Where semaphore signals are used they shall be so arranged as to indicate three positions in the upper left hand quadrant."

PRESIDENT SHANNAHAN:— It is now fairly before the house for discussion. Are you ready for the question on Mr. Henry's amendment?

(A vote was taken on Mr. Henry's amendment and the amendment was carried.)

PRESIDENT SHANNAHAN:— The question now before the house is on Mr. Collins' motion as amended by Mr. Henry.

(On vote Mr. Collins' motion, as amended, was carried.)

MR. WALDRON:— Mr. President, I have lost track to some extent of these proceedings. I would like to have No. 2 as amended read.

The amendment was read by the reporter as follows:

Where semaphore signals are used they shall be so arranged as to indicate three positions in the upper left hand quadrant.

MR. WALDRON:— Mr. Chairman, as a member of this Committee I cannot conscientiously accept the amendment. I believe if the Association were to adopt this amendment it would be doing that which is not best for it to do. I cannot believe that this Association wants to go on record as adopting what is not the best practice.

MR. HENRY:— Mr. President, I asked the chairman of the Committee before I made the motion, whether he meant by No. 2 to recommend semaphore signals. I could not read it quite that way. He said he did. When he said he did I moved to amend it, so as to make it clear that he didn't. Now, this amendment is not saying anything against semaphore signals; it is simply saying how they are to be used, when they are used. I think that is as far as you are ready to go, and I, therefore, am in favor of the amendment as passed by the Association.

PRESIDENT SHANNAHAN:— Mr. Waldron, if you want to bring it properly before the house you will have to move to reconsider it, otherwise we will have to pass to the next.

MR. WALDRON:—I wish some of the gentlemen in the room would discuss this question.

PRESIDENT SHANNAHAN:—There is no question now before the house. In order that the gentlemen in the room may have a chance to discuss this recommendation the Chair will entertain a motion to adopt.

MR. PALMER:— Mr. Chairman, for the sake of disposing of this question finally, I move that the action just taken in adopting this motion be reconsidered.

MR. HENRY:—I move to lay the motion on the table.

(Motion duly seconded, stated and carried without discussion.)

PRESIDENT SHANNAHAN:—The next is upon recommendation No. 3.

MR. HENRY:—I move that recommendations No. 3 and 4 be adopted.

MR. NACHOD:—With respect to recommendation No. 3. After studying this carefully, I cannot see that any system of indications proposed here is adequate for an intermittent contact system. With semaphores the three most suitable would be:

Proceed: semaphore vertical, green light;
Stop and stay: semaphore horizontal, red light;
Proceed under control: semaphore horizontal, red light, yellow light below same.

There is no all-semaphore indication proposed for the latter, and such would be very desirable. These three indications could be used for signals with intermittent control, but another is required of an affirmatory nature, to show that a movement or count has been made in the signal relay to protect following trains entering the block; and for this I have suggested that the yellow light below the red be displayed alternately vertical and staggered. The recommendations do not state whether these aspects are intended to cover intermittent contact systems as well as continuous track circuit systems.

PRESIDENT SHANNAHAN:—Is there any further discussion under Mr. Henry's motion?

(Motion duly seconded and carried.)

PRESIDENT SHANNAHAN:—You have now adopted recommendations Nos. 3 and 4. Recommendation No. 5, reading as follows, is next:

"5. Your Committee recommends, for high-speed interurban service, that automatic signals be controlled by the use of continuous track circuits, and that expenditures be concentrated on continuous track circuit control with a cheaper form of indication in preference to a more expensive form of signal and a less reliable control."

MR. HENRY:—Do you want a formal motion to adopt it before we amend?

PRESIDENT SHANNAHAN:—Yes, there must be. Will some gentleman move its adoption?

MR. HENRY:—I will move its adoption and move to amend afterwards. I move to amend No. 5 to read as follows: Strike out, in the second line the word "that"—the first word of the second line—and the word "be" after the word "signals," and in the third line the word "and" after the word "circuits." I do not object to that for high speed interurban service, except it is useless. Now, Mr. Chairman, my object in making the motion to amend is to limit this recommendation to automatic signals, controlled by the use of continuous circuits and not leave it so that it inferentially recommends automatic signals for continuous track circuits as against everything else. In other words, the recommendation is that expenditures be concentrated on continuous track circuits with cheaper indications. I have no objection to that except I do not like to see it exclude everything else and recommend this.

MR. WALDRON:—Your Committee recommended that which it believed to be the best. It recommended this for the reason that most of the members of the Committee have been connected with signal work covering a considerable length of time. During this time they have seen roads spend a large amount of money in installing signaling systems which did not use the continuous track circuits and after a few years discard such systems as not being satisfactory, and then spend other sums of money installing continuous track circuit systems. Your Committee having in mind the large sums of money which have been wasted on unsafe signaling systems believed it was its duty to recommend for high-speed interurban service that which it believed in the end would be cheaper and better than any other known system. For that reason the Committee recommended No. 5, and as one member of the Committee I would seriously object to having that recommendation changed. I would rather see it stricken out entirely.

MR. HEGARTY:—As I read this recommendation the inference is that if automatic signals are to be used, they should be controlled by continuous track circuits, and, further, if automatic signals are used, that the expenditure be concen-

trated upon the track circuit rather than upon the form of indication. I believe if you look at it in that light recommendation No. 5 would possibly suit Mr. Henry.

Mr. Henry:— Mr. Chairman, I am not hard to suit; I am no stickler on words, but we must take the construction of the chairman on this recommendation as stated by the Committee. I think what he means to do — and he frankly says it, is to recommend as the best practice for this kind of road an automatic signal controlled only by the use of continuous track circuits. That is what he says is meant. The recommendation, however, is that the efforts be centered upon obtaining a cheaper form of indication. I have not any objection to that part of it, but if it is to be construed as the chairman construes it, that No. 5 recommends automatic signals controlled by the use of continuous track circuits against all other signals, I am opposed to it, and I have, therefore, asked that it be amended so as not to hurt the recommendation but to take out the inference which the chairman reads into it. We ought to be perfectly frank here without criticising the Committee, and I think if it meant to say that it recommended continuous track circuits that it should have said so. However, it is mixed in with other recommendations and I want to leave the recommendation, but let it read that the Committee recommends that expenditures for automatic signals where controlled by the use of continuous track circuits, be concentrated on continuous track circuit control, etc.

Secretary Litchfield:—To insure the correctness of the printed proceedings, I would like to ask just what is meant?

Mr. Waldron:—The Committee recommends, for high speed interurban service that automatic signals be controlled by continuous track circuits. The recommendation does not say, that for all interurban service you must use continuous track circuits and automatic signals. As the recommendation is worded, there is evidently some difficulty as to understanding it. I thought that what was said here recommended for high speed interurban service, where automatic signals are used, that those signals be controlled by continuous track circuits.

MR. HENRY:—If the gentleman will make an amendment to that effect I will second it.

MR. WALDRON:—We want to see whether this wording does not bring that out. It seems to me it does.

MR. PALMER:—If I can interpret this recommendation as it is written it means this, that automatic signals in use on high speed interurban service shall not be controlled in any other manner than by continuous track circuits: "Your Committee recommends for high speed interurban service, that automatic signals be controlled by the use of continuous track circuits." I want to protest against confining the method of operation of automatic signals to a continuous track circuit. It is going to shut out any other method of operation entirely and if we go on record in this matter it will confine our use of signals to those controlled by continuous track circuits.

PRESIDENT SHANNAHAN:—I will ask the Secretary to read that again.

(The Secretary read the amended recommendation No. 5 as follows: Your Committee recommends for high speed interurban service automatic signals controlled by the use of continuous track circuits, that expenditures be concentrated on continuous track circuit control with a cheaper form of indication in preference to a more expensive form of signal and a less reliable control.)

MR. FRANKLIN:—I may be a little bit dense, but it seems to me the intention of the Committee was to recommend that where automatic block signals are used they should be controlled by track circuit. If I understand the amendment proper, the amendment permits the use of automatic signals that are not controlled by track circuits. If that is so the amendment is exactly opposite to what the Committee recommends.

PRESIDENT SHANNAHAN:—The question is on Mr. Henry's amendment.

MR. PALMER:—As I understand it, Mr. Henry's amendment is as Mr. Litchfield has just read it.

MR. HENRY:—It is.

MR. PALMER:—I move that the amendment be adopted.

MR. BLAKESLEE:—I am not particularly interested in this question but it seems to me it is not a proper thing to pass this amendment, because it is merely words and means nothing as it is now stated. You say where automatic signals are used that they be controlled by the continuous block circuit rather than some cheaper method of control. Now, the idea of that originally was that automatic block signals for high speed interurban service be controlled by continuous track circuits, rather than overhead wires, conduits, etc., and if it be necessary to economize that it be done in the indicators and that the money be spent for the continuous track control. If we pass this we are simply going around in a circle saying nothing. It would look all right to me to adopt that in such form as to allow other signals besides automatic block signals, but if we are going to adopt automatic block signals at all for high speed interurban service we want to use a continuous track circuit. Now, either we want to drop this thing altogether, or else recommend the continuous track circuit for high speed service where there are automatic block signals.

MR. PALMER:—I call for the question.

MR. WALDRON:— May I make an amendment?

PRESIDENT SHANNAHAN:—You may.

MR. WALDRON:—I move that recommendation No. 5 be eliminated and referred back to the Committee for further consideration.

(Motion duly seconded.)

MR. HENRY:—There is one good feature in this recommendation: I have had the pleasure of acting with the Committee in our state and I know what these gentlemen have developed in the way of continuous track circuits, automatic block, and this recommendation shows, where you are using the continuous rail automatic block that you should concentrate all of your energies and expenditures on cheapening the devices. We do not see any objection — in fact I think it would be a good thing, that this recommendation should stand, recommending to the Association that they bend

their energies to cheapening devices for giving signals. It does not hurt the other proposition in the least. I am not fighting continuous rail automatic propositions. I say this continuous rail proposition is a good one.

MR. PALMER:—I hope that the amendment to the amendment will be voted down. There is a very large and active representation of the member companies here; this matter has had full discussion and I think it ought to be settled now. I hope the amendment to the amendment will be voted on, which will leave us free to accept the motion as originally put, and I think we ought to stand on that; to come right back to the motion as originally amended and have an expression on it.

MR. ROCKWELL:—I would call for the question.

PRESIDENT SHANNAHAN:—The question is on Mr. Waldron's amendment to Mr. Henry's amendment to the effect that recommendation No. 5 go back to the Committee and be eliminated from this report.

(A vote was taken on Mr. Waldron's amendment, which carried.)

PRESIDENT SHANNAHAN:—The next is recommendation No. 6.

MR. ADAMS:—I move that the sixth recommendation be adopted.

(Motion duly seconded, stated and carried.)

MR. CHOATE:— Now I move that the recommendation be adopted as a whole.

MR. HENRY:— Changing the numbers, of course.

(Motion duly seconded, stated and carried.)

PRESIDENT SHANNAHAN:—The next business before the house is the report of the Joint Committee on Train Operation and the Chair requests the gentlemen to come to the front.

MR. SAWYER:— Mr. Chairman and gentlemen, the Committee's instructions as outlined at the winter meeting, were that we were to consider both city and interurban service. The members of the Committee who have been considering interurban service in connection with train operation, desire

to report progress, and the report, therefore, for to-day will be restricted entirely to city service. In order to draw direct financial conclusions which will be comparable for all cases, it was necessary to start in and make several assumptions, which remained the same throughout all cases. I wish you particularly to note that the prices, which in some cases, may be high, and in other cases low; but in all cases we have tried to make them comparable.

In the second part there are very few details that require your attention. This report was written about six months ago and the figures to-day are different from what they were then. As you go through these figures I think that you will find that none of them unduly favor the multiple operation; where favor is shown it tends to help single car operation.

There is a combination of multiple-unit cars which was not shown on the "Direct Financial Conclusions" sheet that appeals to me very much, eradicating to a certain extent the old question of two and four-motor equipments, that is, to use two-motor multiple-unit cars in the summer time all day long, putting on the four-motor multiple-unit equipment during the rush hours, thus carrying the bulk of the traffic with the lighter two-motor equipments in the summer time when the track conditions are such that the two-motor equipment will take care of the service.

REPORT OF JOINT COMMITTEE ON TRAIN OPERATION

To the American Electric Railway Engineering and the American Electric Railway Transportation and Traffic Associations:

GENTLEMEN:— The subject of the investigation of train operation was assigned to your Joint Committee by action of the Engineering and Transportation and Traffic Association Executive Committees at their mid-winter meetings, with instructions that the subject be investigated from the standpoints of congested city and interurban service.

The subject of city service has been considered by Messrs. Benedict, Lindall, Jones, Kilbride, Adams and Sawyer, of the Joint Committee and the interurban service has been considered by Messrs. Crume and Stevens.

The Joint Committee has held three meetings; the first at the headquarters of the Association in New York, on January 25, at which were present Messrs. Jones, Kilbride, Benedict, Adams and Sawyer. At this meeting the general outline of the Committee's work was approved.

A second meeting was held at the headquarters of the Association on April 25 and 26, at which were present Messrs. Kilbride, Crume, Benedict, Adams and Sawyer. A comprehensive outline of the report was presented at this meeting and the details of the same were discussed by the Committee.

The third meeting was held at the headquarters of the Association on July 16, at which there were present Messrs. Jones and Kilbride, of the Transportation and Traffic Association and Messrs. Benedict and Adams, of the Engineering Association; in addition Mr. Jackson, of the Public Service Railway Co. of New Jersey, representing Mr. Danforth, and Mr. Gray, of *Electric Traction* and Mr. Kingsley, of the *Electric Railway Journal* also attended this meeting.

PART 1, CITY SERVICE

The report pertaining to city service has been subdivided into two parts — Part 1 gives briefly the essentials, conclusions and recommendations of your Committee, and Part 2 takes up the assumptions and explanations in considerably more detail.

In order to make comparisons of single car operation, multiple-unit operation and trailer car operation, both with two motors and with four motors, your Committee first carefully laid out a schedule and compiled the costs per year on a hundred car basis of (1) Fixed Charges, (2) Platform Expenses, (3) Maintenance and Inspection, (4) Power, for Cars Equipped with 2–55 H.P. and K Control and Operated as Single Cars in Congested City Service. These costs were in the main taken from actual service data and this type of car and equipment is later referred to as A1. After the data on A1 had been compiled, the Committee worked out comparative data and costs for several other combinations of two and four motor single car operation, multiple-unit and trailer operation, upon the following examples, as explained more fully in Part 2.

A2 Two-motor, double end equipments, 55 H. P., with four-motor K controllers and coupler cables between the cars, so that two two-motor cars can be operated in a train. To be operated as single cars, except from 6 to 9 A. M. and from 4 to 6 P. M., when they are operated in two-car trains.

A3 Two-motor, double end equipments, 55 H. P., with multiple-unit control, operated as single cars, except from 6 to 9 A. M. and 4 to 6 P. M., when they are operated in two-car trains.

A3A Two-motor, double end, equipments, 55 H. P., with multiple-unit control. Operated in two-car trains, except from 6 P. M. to 6 A. M., when they are operated as single cars.

A4 Four-motor, double end equipments, 30 H. P., with K control. Operated as single cars all day.

A5 Four-motor, double end equipments, 30 H. P., with multiple-unit control. Operated as single cars, except from 6 to 9 A. M. and 4 to 6 P. M., when they are operated in two-car trains.

A6 Four-motor, double end equipments, 30 H. P., K control. Operated as single cars, except from 6 to 9 A. M. and 4 to 6 P. M., when 53 motor cars are operated as single cars and 26 motor cars in trains with an equal number of trail cars.

A7 Four-motor double end equipments, 37 H. P., K control. Operated as single cars, except from 6 to 9 A. M. and 4 to 6 P. M., when 52 motor cars are operated in trains with an equal number of trail cars.

The important general assumptions for the comparison of the above examples of two car train vs. single car operation are approximately as follows:

Schedule speed 8½ miles per hour for rush hours, except trailer operation, which is taken at 4 and 5 per cent. less, due to less horse power per ton of train.

Rush-hour headway not exceeding 2 minutes for single car operation with 100 cars in operation during rush hours and 50 cars during midday.

Seating capacity of all cars 60.

Car mileage and receipts per car mile the same in all cases.

Fixed charges, covering interest, depreciation, taxes and insurance, 12 per cent.

Platform expenses, 25 cents per hour per man.

Total cost of power at the car $0.0125 per K. W. H.

"Train operation" covers two cars only, in train.

All cars of single, combined entrance and exit type for double end operation and equipped with improved devices for handling passengers and reducing accidents.

It should be noted that the above conditions were those assumed for the purpose of drawing direct financial conclusions, but by making these assumptions, the Committee is not taking the ground that train operation should be confined to the limits above.

Maintenance and inspection costs were taken as far as possible from records of operating companies, with the exception of the newer apparatus, such as multiple-unit control, this particular item being taken at 50 per cent. more than for corresponding K control. Operating costs which do not vary for the different equipments have not been included. Weights and prices were taken after discussions between the Committee and representatives of manufacturers. Energy consumption and power cost figures were taken mainly from actual tests and the average of a number of the larger power installations. In figuring costs, weights and service, particular attention was given to making all cases directly comparable one with the other.

Based upon the above assumptions and explanations, the following statement shows the financial results per 100 cars per year figured by your Committee for the various cases:

Direct Financial Conclusions Per 100 Cars Per Year.

Class	Type of Equipment and Character of Operation	Fixed charges	Platform expenses	Maintenance and inspection	Power	Total
A1	Two 55 hp. motors, K control, single car operation all day...	$58,968	$192,237	$60,500	$108,716	$420,421
A2	Two 55 hp. motors, K (4 motor) control; single car operation except 6 to 9 A. M. and 4 to 6 P. M. when operated in trains...	64,282	171,884	64,057	108,030	408,253
A3	Two 55 hp. motors, multiple-unit control, single car except 6 to 9 A. M. and 4 to 6 P. M. when operated in trains.....	64,800	171,884	64,430	108,135	409,249
A3A	Two 55 hp. motors, multiple-unit control, train operation except 6 P. M. to 6 A. M.....	64,800	157,828	64,430	105,588	392,646
A4	Four 30 hp. motors, K control single car operation all day....	68,299	192,237	66,902	127,189	454,627
A5	Four 30 hp. motors, multiple-unit control single car operation except 6 to 9 A. M. and 4 to 6 P. M. when operated in trains.....	74,390	171,884	70,832	125,948	443,054
A6	Four 30 hp. motors, K control, single car operation except 6 to 9 A. M. and 4 to 6 P. M. when 53 of the motor cars are operated singly and 26 are operated in train with an equal number of trail cars	64,215	185,615	70,348	120,913	441,091
A7	Four 37 hp. motors, K control, single car operation except 6 to 9 A. M. and 4 to 6 P. M. when 52 motor cars are operated in train with equal number of trail cars.	55,962	178,709	65,165	116,423	416,259

Note.— Statement A (page 332a) gives the general operating data from which the above direct financial conclusions were figured, and the unit car and train schedule tables give all schedule details. This statement and both schedules are attached to Part 2.

It will be noted from the above statement that where multiple-unit equipment is used and trains operated during the rush hours, the cost of maintenance, fixed charges, platform expenses and power is slightly less than the single car operation with K control, and where multiple-unit is used from 6 A. M. to 6 P. M., there is a decided advantage over the single car operation. The trailer operation, in the comparison of the four-motor equipments, is even cheaper than the multiple-unit operation and shows that where trailers can be used with all of the motor cars during the rush hours the extra cost of the larger motors is more than counterbalanced by the saving due to purchasing less motor cars and more trailers.

The conditions assumed as to cars, equipment, service, etc., are to a certain extent theoretical, and the conclusions are not applicable to all conditions, although your Committee believes that they represent as nearly as possible an average condition covering congested city operation, and for the types of equipments considered are comparative. The two-motor car combinations are submitted to meet operation where equipments of this character may be used, likewise the four-motor combinations cover conditions where they are needed, and the trailer operation still another condition, it being the judgment of your Committee that local conditions must dictate as to the combination to be used and it not being the intention of the Committee to compare two-motor and four-motor equipments.

Indirect Financial Conclusions

In addition to the direct financial conclusions as shown in the statement, your Committee submits the following:

1. The loss of time due to extra or longer stops involved in train operation will be offset by the saving in the reduction of traffic interferences and at car crossing intersections, and the schedule speed will be as high in train service as in single car service, where all cars are equipped with motors of the same size. The above is a general statement based on analysis of service tests covering average conditions of traffic interference and schedules. If the interference from traffic is abnormally high, the schedule speed will be materially increased with train operation, and if abnormally low, it will be decreased due to a greater number of, or longer, stops. Due to the varying local conditions, your Committee did not attempt to capitalize the increase in schedule speed where delays from traffic are abnormally high, but it is apparent that where this condition exists and also on lines or portions of lines where cars are of necessity operated at such close intervals that the efficient track capacity has been exceeded, two-car train operation will be of considerable benefit in increasing schedule speed.

2. The total accident cost will not be increased, and accidents, due to collisions, will be reduced. This statement is based upon the assumption that modern cars and appliances are used, where all entrances and exits are protected with doors and the boarding and alighting of passengers is only permitted when the train is stopped.

3. No advantage has been credited to the use of trains for emergency service, such as base ball games, circus day traffic, park and picnic traffic, but it is evident to your Committee that there are a number of occasions each year in the various cities where train operation could be put into service instead of single cars to meet the emergency conditions as to travel in a more satisfactory manner and with increased revenue.

4. Where headways in single car operation are now at a minimum, it is possible to install train service and carry additional passengers with an increased net financial result over and above the results shown in the table. This is due to the fact that train service permits a greater number of cars to be operated over the same given trackage.

General Conditions

The selection of the type of equipment to be used, as stated above, depends upon local conditions. In the four-motor cases the cheaper train, involving the trailer, may not be applicable to all conditions, as the question of grades, character of terminals, minimum headways, density of traffic, etc., may make the operation of the same unsatisfactory, but there are many cities where trailer service could be used at least to a limited extent, with considerable saving over single car operation. In cases of extreme density of traffic, the multiple-unit train is to be preferred over a motor car with trailer, as the interruption of one train may be more serious than under conditions where the traffic is not so dense. The more flexible multiple-unit train, either two or four motor, would warrant its installation in the more extreme congested conditions.

Improvement in the art has made train operation much more practicable to-day than in the past, and in comparing single car and train operation this fact should receive prominent attention and train operation should not be condemned due to past faults either of equipment or operation. The single combined entrance and exit car particularly lends itself to this character of service, and if equipped with doors opened only when the car stops, throws a safe-guard around the operation. The introduction of combination couplers, including the air, has simplified the problem of train operation. The coupler situation is not as satisfactory for city cars as is desirable, but with the improvements now under way train operation should be practical and successful in so far as couplers are concerned.

The air brake equipments of to-day are so designed as to meet the train service satisfactorily, and with the straight air emergency combination, two-car trains are handled with safety. With reference to the use of multiple-unit control, your Committee, after giving this question careful study, believes that multiple-unit apparatus as now manufactured is practicable for city service and the Committee hopes that the near future will bring forth further developments in the design of lighter weight and lower cost multiple-unit control equipments.

Recommendation

Your Committee especially desires to recommend, in regard to this city service problem, that the operating officials of city properties give the subject of two-car train operation serious study and attention, as it

is the belief of the Committee that a distinct saving is to be made by train operation during certain periods of the day over portions of the system. In recommending this study, they desire to emphasize the fact that it should be made from the standpoint of modern equipment, as they feel that the equipment of to-day has brought about a condition which makes the operation of trains much more attractive than in the past, and that, by the operation of two-car trains in place of single cars, under congested conditions a vastly improved service may be given which can only be considered by the public as an endeavor on the part of the company to better the conditions of the service.

PART 2, CITY SERVICE

This portion of the report covers the same general ground as Part 1, but it is the intention, in this section, to go into the discussion in detail and make the statements more specific rather than general, as they are in Part 1. While in certain cases individual figures may be open for discussion, it has been the endeavor of the Committee to make all figures comparable.

Schedules and Platform Expenses

In order to make definite comparisons of the different classes of service, the Committee had prepared two 24-hour schedule tables: (1) single car operation all day; (2) two-car train multiple-unit operation during the rush hours with single car operation during the rest of the day. These two tables are attached hereto and serve as a basis for all schedule data, as the schedules for multiple-unit operation from 6 A. M. to 6 P. M. for trailer operation and for other combinations were based directly and are comparable to the two tables. The schedule speeds are the same in all cases, except for the train operation involving the use of trailers, which, in the case of the 4–30 H.P. motors (A6), was taken at 5 per cent. slower and with the 4–37 H.P. motors (A7) at 4 per cent. slower. These tables are made out on the basis of 50 car maximum operation, and, in order to meet the conditions assumed by your Committee of 100 cars in maximum service, the tables are to be doubled as to car hours, mileage and costs; thus while the minimum headways are shown as two minutes and four minutes respectively on the unit car table and on the train table, the headways will be respectively one and two minutes on the basis assumed by your Committee. These tables are based upon the assumption that the schedule speeds in these two cases are the same and the average schedule speed throughout the day of 24 hours is 8.81 m. p. h. Your Committee decided to use the basis of 100 cars for convenience in figuring, but by so doing they did not intend these figures to be taken as applying to only a "hundred car system," as no specific number of cars have been assumed for the entire system. While headways of one and two minutes are used in the tables, the principle of train operation may be

applicable to conditions where headways are even as long as 10 and 15 minutes with train service. In fact, there are instances where train operation is now being used practically and profitably where headways are as much as 10 minutes, and there are many other conditions than those assumed where train operation is practicable.

From the recapitulations on these two tables giving the data as to car hours, car miles, headways, time of runs, etc., it will be noted that the table covering the train operation requires 17 less men than the unit car table. This means 34 men on the 100 car basis. In the case of the train table, the crews have been shifted in such a way as to require that some of the conductors shall, at certain times, assume the duties of motormen, or vice versa. This procedure is not necessary but it is practicable for train operation and by shifting the men in the crews in this manner, the train table would be made up to better advantage for the platform men and also contain fewer short runs. The car hours covering the platform expense as obtained from the tables are the same in all cases, with the exception of the trains where trailers are used, in which case allowances are made to meet the slowing down of the schedules. The rate per hour is assumed at 25 cents per man, which gives a platform expense for the single car per hour of 50 cents and of 75 cents per hour for the train, or 37½ cents per hour for each car in the train on the average. Although the platform wages for these tables cover the exact amount of time as shown upon the tables, the Committee realizes that this is not universal practice, but they consider that for the purposes of this report the expense is comparable. On the unit car table, there are 64 runs averaging 9 hours and 15 minutes, and on the train table there are 57 runs, averaging 9 hours and 20 minutes.

In figuring the number of days per year for the operation of the car, your Committee arbitrarily assumed 325 days in order to reduce the complication in figuring mileage, platform expense, etc., by the year, and is supposed to represent 325 full days of service as applying to the tables assumed.

Car Miles

Car mileage of 33,875 per car per year is assumed to be the same in each case in order to make a true comparison. This is an item which might vary somewhat under actual conditions, but for the purposes of this report and for comparison your Committee has considered it preferable to assume the same mileage for each class of operation and allow the schedule speeds and the car hours to vary.

Construction Costs and Weights

The weight and first cost figures received careful consideration from your Committee and were only determined after frequent conferences with the manufacturers interested, and after due allowances had been

made in both for variations in details of the equipments. The figures submitted are for the complete equipments covering car body and all accessories, trucks, electrical equipment, air brakes and the cost of installation. The basis of all prices is f.o.b. manufacturer's works, having been taken in this manner, in order to eliminate the variable item of the cost of freight. In connection with the prices obtained for car bodies, your Committee investigated the question of the cost of center entrance cars as compared with cars having platforms at both ends, and they received assurances from manufacturers that cars of this type, having the same general principles of design, would cost little, or no more, than cars of the other type, and from the standpoint of weight, there would be practically no increase and very probably a decrease in weight in the case of the center entrance car. In the case of the trail car, owing to the absence of motorman's cabs at each end of the same, it was possible to make the car shorter, keeping the seating capacity the same and allowances were made in both cost and weight to compensate for this fact, allowances were also made for the fact that the trail car would be lighter in the superstructure, as it did not have to carry a trolley. It is assumed, for estimating purposes as to cost and weight, that the car bodies have a steel underframe and wooden superstructure. In the electrical equipments, standard motors with commutating poles are estimated upon having standard insulation. In the car body wiring, semi-conduit insulation is assumed, allowances being made in both the cost and weight figures for even such an item as the variation in the amount of conduit used on the different cars. An allowance of approximately 18 per cent. increase in cost of the two-motor electrical equipment was made for multiple unit over K control. The difference in weight in these cases is approximately 480 lb., showing that the later types of multiple-unit control have been materially reduced in weight from the earlier types. In the air brake equipment, an allowance is made between the single car and the multiple-unit car operation of 200 lb., which is made up of the additional valves, reservoirs, piping, etc., made necessary in this last mentioned equipment.

The car construction cost figures are used only for obtaining the fixed charges, which were arbitrarily taken at 12 per cent. The Committee disclaims any intention of setting 12 per cent. as either correct or incorrect, but has used this figure in each case and the results are therefore very closely comparable.

The figures of weights were obtained for the purposes of the power consumption, and no allowance has been made for the effect of weight in any other part of the operation, such as wear and tear on track, special work, etc.

Maintenance and Inspection

In obtaining figures for the maintenance and inspection charges, your Committee made a careful study relative to the same, obtaining figures from operation wherever possible, and after establishing a basis, made all other figures comparable. As examples, in car body maintenance allowance is made for the increased cost of maintenance where combined couplers are used in the train operation over single car operation; in truck maintenance an allowance is made between the cost of maintenance of the single motor truck as against the two-motor truck and the motor maintenance allows for the difference between the sizes and service of motors and the number of motors per car. In determining the figures for the cost of maintenance for control and miscellaneous electric, your Committee encountered the greatest difficulty, particularly in the maintenance where multiple-unit control is involved, and after looking over the figures obtained from companies using multiple unit, the Committee came to the conclusion that there was no actual comparable data on which they could base the maintenance figures for this type of control. After a large amount of time was consumed in the discussion of this subject, your Committee decided, in conjunction with representatives of the manufacturers, that an increase of 50 per cent. be made for the maintenance of multiple-unit control over that of K control, these figures applying to congested city service. The manufacturers do not admit that maintenance of multiple-unit control will be 50 per cent. over that of K control, but this is a comparatively small percentage of the total.

The cost of inspection covers the renewal of brushes, cost of lubrication and the expense of inspecting the equipment upon a mileage basis assumed at about 800 miles per equipment.

Items in the operating expenses which are common to all equipments, such as car cleaning, are not included in the maintenance and inspection figures.

Air Brakes

Your Committee has considered that each car would be equipped with air brakes and in the case of the single car equipments with what is known as the straight air type. All of the other equipments are of the straight air emergency type, so arranged that if the coupling on the train parted at any time, the brakes would immediately be set in an emergency position. In the case of two motor cars operated together with multiple-unit control, each car in the train is to be equipped with a motor driven compressor. Where a trailer is used, the motor car alone is equipped with the compressor and the trailer with only such apparatus as is necessary for the service, such as brake cylinder, reservoir, emergency and conductor's valves, etc.

Passenger Load

The passenger load is assumed at an average of 25 passengers, weighing 140 lb. each. This passenger load is assumed the same in each case and for all the cars.

Power

The energy consumption in kw-hours per ton mile is an item which is, of course, open to considerable discussion. Your Committee appreciated that great variation might be found in figures of this character, and after collecting considerable data from certain known operations and published data, the figures assumed were then checked by representatives of the large manufacturing companies who make a specialty of this work, and they believe that these assumptions are comparative for the different conditions assumed; it must be particularly noted that the figures given for energy consumption are taken at the car. It is, of course, well known that the energy consumption per ton mile for a train is less than for a single car, and the figures illustrate the same.

The cost of power, $0.0125 per kw. hour, is lower than the actual total cost of current at the car for the average city electric railroad and is purposely taken lower in a desire to be conservative and also due to the fact that some of the items entering into the total cost of power are not appreciably affected by comparatively small variations in the amount of power. The total cost of power should take into account operation and maintenance of power house, high tension transmission system, sub-station and low tension distribution system and also fixed charges covering interest, depreciation, taxes and insurance on all of the above items, and cost at the car must take into account all losses between the power house and the car. This total cost of power at the car amounts in extreme cases to over 2 cents per kw. hour, but for the purposes of this report, we believe it fair, as stated above, to use the figure $0.0125. The power costs were taken the same for every hour of the day, although admittedly the cost is less at the non-peak hours and if this fact had been taken into consideration, it would have made a slightly better comparative showing for the heavier motor car (A7) that carries an excess weight in motor capacity over what is needed for non-rush hours when the trailer is not used.

Motor Capacity

For the two-motor equipments it is assumed that 2–55 H.P. 600 volt motors will be sufficient to meet the requirements of the service and that the temperature rises of these motors after all day service terminating in a rush-hour will not exceed 60 degrees C. rise. For the 4–30 H.P. motor equipments, it is assumed that for the single car and the multiple-unit operation these motors would meet the requirements of the service satisfactorily with approximately the same temperature rise

of 60 degrees C. In the case of these 4–30 H.P. motors used at times to pull a trailer (A6) it is assumed that 53 of the motor cars will be used as single cars and that 26 of the motor cars will haul trail cars during the maximum rush hour period, also that the 26 motor cars used to haul trailers will be taken out of service until the next rush-hour service. On this basis, the temperature rise of the motors on the cars pulling the trailers should not exceed 65 deg. C. rise. With the 4–37 H.P. motor (A7) equipment the temperatures should not exceed 65 deg. C. rise even if used to pull a trailer all day long.

Trailer Operation

The A6 case of 4–30 H.P. motors hauling a trailer during rush-hours only is submitted in this report to show, not so much the advantage of purchasing equipments of this character new for this plan of operation, but to show how it is possible to utilize four-motor equipments, that are now in operation, in conjunction with trail cars, and the Committee has in mind that there are a number of cases where, by the purchase of trail cars alone, additions can be made to the service at an initial expense considerably less than by the purchase of new motor equipments, and in addition, that a saving in operation could be made by the use of equipments of this character rather than by additional four-motor cars. In this A6 case all the motor cars are equipped with couplers and all equipment, so that any of the motor cars can be run pulling a trailer car. If the service was such that the 26 motor cars could be set aside and only used in the trailer service, the remaining 53 motor cars would not need to be equipped with couplers or for train operation and the cost given would then be somewhat reduced. The primary objection to the plan of using motor cars to pull trailer cars where the motors have only sufficient heat capacity to normally run singly all day is that motor cars should never be used to pull trailers except after they have been standing in the barn and are not up to or near maximum temperature. With the motor car equipped to pull a trailer, there is always the possibility of misuse by using the motor car to pull the trailer all day long for emergency service. With motors of only sufficient capacity for the car to run singly, it must be distinctly understood that the Committee makes no definite recommendations regarding this, other than to show that it is a most economical operation if the motor cars are utilized to pull trailers only to the extent assumed by the Committee. The Committee's particular reason for taking this example is that there are to-day many cases where cars are sent out of the barn only for morning and evening rush to handle a factory or shop load which could be more economically handled by trailers as outlined above than by single car operation.

The broader trailer proposition is covered in the A7 equipment, having 4–37 H.P. motors where the motors are of large enough capacity that if need be the car could haul a trailer all day long without undue heating, which would cause excessive deterioration of

insulation. In this case, the motors and air compressor are both approximately 25 per cent. larger and of course, when trailers are not being hauled, this excessive cost and weight mitigates against the equipment, but, as shown by the figures given in the statement of the Direct Financial Conclusions in Part I, the net result is very economical, and where the service conditions do not demand the more flexible multiple-unit train, this equipment can be used to advantage and should, in the opinion of the Committee, be used much more generally than it is to-day.

To sum up: the 4–30 H.P. motor equipment arranged for using a limited number of trailers during rush-hour only is more economical than the same motor cars used only in single car operation, and is particularly applicable to the handling of shop and factory crowds. If trailer operation is to be taken up, to obtain the full advantage of same, the 4–37 H.P. motor (A7) car arrangement should be used and shows even a more decided gain, due to the fact that in this case the trailers are used to a greater extent.

Another very good combination which is not worked out would be to equip the 4–30 H.P. motor cars with multiple unit and then make up 26 trains of two multiple-unit cars and also 26 trains of one multiple-unit car and a trailer car. This gives a more flexible arrangement than the K control, and an arrangement which costs less money than A5 where the 100 4–30 H.P. motor cars are equipped with multiple-unit control. Trailer cars will consume more time in coupling than multiple-unit cars, but in some instances this saving of time is not of as primary importance as it is in others, and with proper attention to this detail, the time of coupling even in trailer cars can be materially cut down over what is generally assumed as necessary. It should be distinctly understood that wherever the Committee refers to trailer operation it is assumed that the trailer car is equipped with every device for the comfort and safety of passengers that the motor car has. The Committee appreciates that the trailers can be used to advantage without all of these improvements and that some local conditions will justify the further saving which is to be made by rebuilding cars for trailer operation, or possibly in some few cases by making alterations only in present older cars for use as trailers, but we believe it unwise to try to save too much money in this direction, as the full advantage of trailer service may not be secured.

Two-Car Trains Equipped with Total of 6 Motors

Where the trains of two cars, consisting of a 4–37 H.P. motor car (A7) and trailer, will not meet the conditions, and where the use of two four-motor multiple-unit control cars more than meet the conditions, it is possible to operate two cars in the train, one of which is equipped with four motors and the other with two motors, and both with multiple-unit control. This makes an equipment which does not cost as much as the two four-motor cars equipped with multiple-unit control,

and yet has practically all the flexibility of the last-mentioned equipment. Although this particular case has not been worked out in detail, a fair figure for the cost of operation for the year is obtained by averaging the cost of the third and sixth cases, as shown in the Direct Financial Conclusions. This is a total for this combination of $426,151. This figure shows that an economical combination can be worked out, and in a city where the crowds and service are such as to require a combination such as this, good results can be obtained. During the winter months, when the four-motor equipment may be necessary due to track conditions, the four-motor car can be used singly during the middle of the day and coupled up with the two-motor car during the rush-hours, while in the summer time, when four motors are not necessary, the two-motor equipment can be used during the middle of the day.

Schedule Speed

As previously stated, the schedule speed is assumed the same for multiple-unit operation as for single car operation, always bearing in mind that the equipment and service is the same. At the time of writing this report, train operation has not yet progressed in actual practice to a point which would enable the Committee to secure definite data to prove this point, and even actual tests, under comparable conditions, will only show the results for the particular local conditions of the service. From tests which were made for the purposes of obtaining data for this report, we are unable to quote figures, as there were not enough multiple-unit trains in service to get a fair comparison, and further, the multiple train was new in the service, which always mitigates against obtaining reliable results. From an analysis of these tests, it was apparent, as will be expected, that the number of stops per mile will be slightly increased by train operation, but where the stops per mile are already high, this item, by itself, will not materially decrease the schedule speed. On the tests there were an average of approximately 9½ stops per mile with the single car and 10 with the multiple-unit train.

The length of stop will be slightly greater with train operation than with single car operation, due to the fact that the time for passenger interchange per car will vary for the two different cars of the train due to unequal loading, and that the whole train is held up for the length of time necessary for the passengers to get on or off from the car which has the greatest interchange at that point. This interchange may vary from car to car at different points, but every time both cars are held the maximum time. There will also necessarily be a slight delay due to transmission of signals on the train. The education of the public to train operation will cut down the length of stop so that it closely approaches single car operation, and a study of the best method of transmitting signals will make this delay of minor importance.

To offset the increased number of, or length of stops, there is the gain in schedule speed due to the less interruption per car from traffic interference. The maximum schedule speed of a line is dependent upon the maximum schedule speed of the slowest car on that line, and with traffic interference practically cut in half by train operation, the increase in schedule speed from this item alone in the districts with congested traffic will by itself practically offset the loss in number or length of service stops.

The use of two-car trains as against single car will facilitate the movement of cars past congested intersections, as it is possible to materially increase the number of cars passing given intersections by the use of trains. Detail figures showing the gain in schedule speed could, at the best, only be given for particular local conditions, and therefore would not be of general value, but it is most noticeable, without further demonstration, that at the prominent intersections in all of our large cities, two-car trains would materially improve the movement of cars past these intersections. The Committee therefore feels justified in saying, even without the absolute proof and ability to give detailed figures, that, *in general,* the schedule speed will be as high with two-car multiple unit trains as with single car operation.

Multiple-unit equipment and couplers with combined draw-bar, air and electrical connections would make possible the consideration of coupling single cars into trains over the more congested portions of a route, and running as single cars over the remaining portions of the route. When the Committee first took up work on this report, it was not considered practicable for them to assume the coupling of cars together over portions of the route only in this manner, as the problem of designing such a coupler that would be mechanically and electrically satisfactory and still not be too cumbersome was considered to be a very difficult one. However, if such a coupler is developed, enabling cars to be coupled and uncoupled almost automatically, there are many congested points through which the cars could be run more expeditiously as two-car trains than single units and with some further increase in schedule speed — although no saving in platform expense is figured or expected. The Committee sincerely hopes that the coupler manufacturers recognize the need of a satisfactory coupler combining these features.

Although all of the factors referred to above are applicable to trailer operation, the same must naturally result in slower schedule speed than multiple-unit operation. When the Committee assumed 4 per cent. and 5 per cent. slower schedule speed for the two different trailer car equipments, their conclusions were based upon the weights of cars and sizes of motors assumed. In some instances trailers are used today with a slowing down of schedule speed of approximately 10 per cent., and even then show a distinct financial gain.

STATEMENT A

Class	Type of Equipment	Operating data									Direct financial conclusions				
		Number of cars purchased	Miles per day		Car-hours		Maintenance and inspection cost per car-mile	Kw. hours per ton-mile		Tons per car with passenger load		Price of equipment	Fixed charges	Platform expenses	Maintenance and inspection	Power	Total
			Unit car	Train	Unit car	Train		Unit car	Train	Unit car	Train						
A1	Two 55 hp. motors K control; single car operation all day	108	10,423	.....	1,183	.....	0.01786	0.130	.....	19.75	.....	$4,550	$58,968	$192,237	$60,500	$108,716	$420,421
A2	Two 55 hp. motors K (four motor) control; single car operation except 6 to 9 A. M. and 4 to 6 P. M. when operated in trains	108	6,049	4,374	682	501	0.01891	0.130	0.120	20.28	20.28	4,960	64,282	171,884	64,057	108,030	408,253
A3	Two 55 hp. motors multiple-unit control; single car operation except 6 to 9 A. M. and 4 to 6 P. M. when operated in trains	108	6,049	4,374	682	501	0.01902	0.130	0.120	20.30	20.30	5,000	64,800	171,884	64,430	108,135	409,249
A3A	Two 55 hp. motors multiple-unit control; train operation except 6 P. M. to 6 A. M.	108	2,959	7,464	336	847	0.01902	0.130	0.120	20.30	20.30	5,000	64,800	157,828	64,430	105,588	392,646
A4	Four 30 hp. motors K control; single car operation all day	108	10,423	.....	1,183	.....	0.01975	0.135	.....	22.25	.....	5,270	68,299	192,237	66,902	127,189	454,627
A5	Four 30 hp. motors multiple-unit control; single car operation except 6 to 9 A. M. and 4 to 6 P. M. when operated in trains	108	6,049	4,374	682	501	0.02091	0.135	0.125	22.74	22.74	5,740	74,390	171,884	70,832	125,948	443,054
A6A and *A6B	Four 30 hp. motors K control; single car operation except 6 to 9 A. M. and 4 to 6 P. M. when fifty-three of the single motor cars are operated single and twenty-six are operated in train with an equal number of trail cars	85	8,236	.....	945	.....	0.02203	0.135	.....	22.46	.....	5,430	.....	.....	.....	.....	.....
		.....	.....	2,187	.....	263	.....	.....	0.123	.....	17.81	.....	64,215	185,615	70,348	120,913	441,091
		27	.....	.....	.....	.....	0.01000	.....	.....	.....	.....	2,725	.....	.....	.....	.....	.....
A7A and *A6B	Four 37 hp. motors K control; single car operation except 6 to 9 A. M. and 4 to 6 P. M. when fifty-two motor cars are operated in train with equal number of trail cars	56	6,049	.....	709	.....	0.02169	0.133	.....	23.55	.....	5,700	.....	.....	.....	.....	.....
		.....	.....	4,374	.....	521	.....	.....	0.121	.....	18.35	.....	55,962	178,709	65,165	116,423	416,259
		54	.....	.....	.....	.....	0.01000	.....	.....	.....	.....	2,725	.....	.....	.....	.....	.....

* A6B denotes the trail car.

FIG. 1. STATEMENT A — GENERAL OPERATING DATA AND DIRECT FINANCIAL CONCLUSIONS

Unit LINE Weekday TABLE NO. IN EFFECT 19 SUPERSEDING NO.

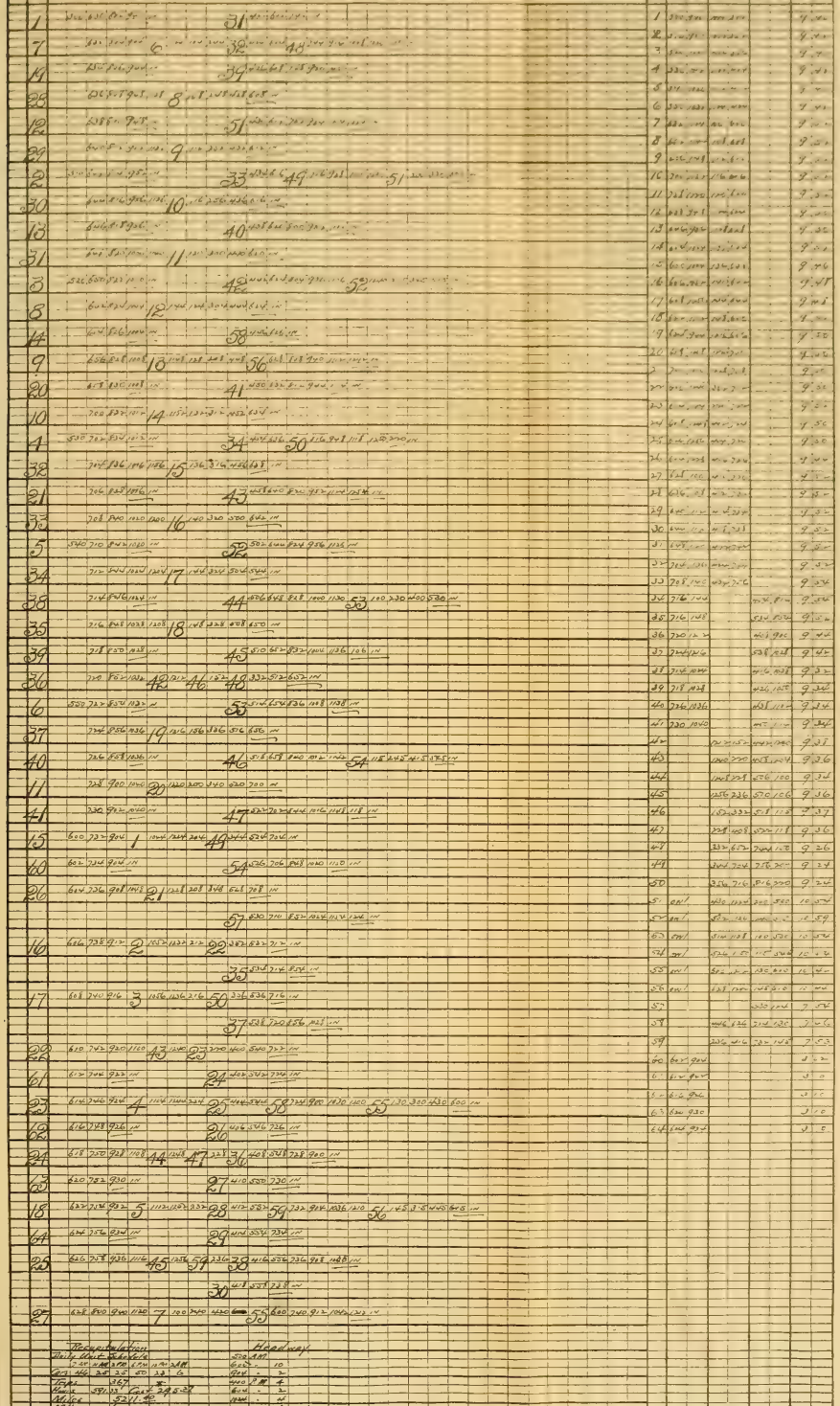


Fig. 2. Schedule Showing Single Car Operation

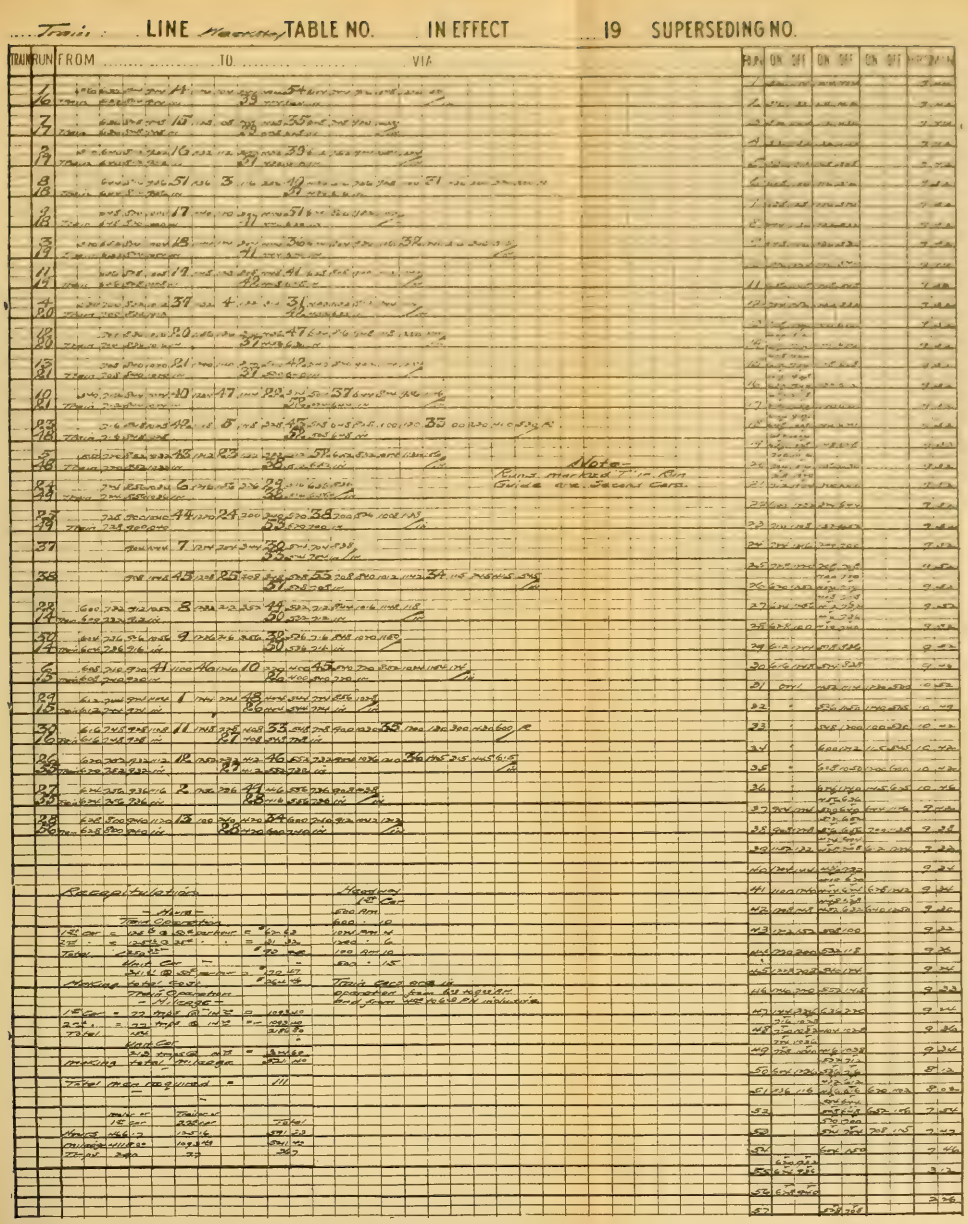


Fig. 3. Schedule Showing Train Operation.

Accidents

As stated in the first part of this report, the Committee does not consider that the accidents would be increased by the use of trains of the type under consideration by the Committee, as compared with single car operation. One large factor which enters into this particular question is that of knock-down and collision accidents and, from the standpoint of per car operated, these would be reduced.

Electric Signaling Device

Where train operation is involved, your Committee has considered an electric signalling device to communicate the signals to the motorman as an essential part of the equipment, as it will be necessary to transmit promptly a signal to stop or start from the rear to the forward car. At the present time, there are several devices of this character upon the market which meet the condition of this service satisfactorily

General

All the manufacturing companies interested have co-operated with your Committee to the fullest extent possible, several of them sending representatives to our meetings. The member companies whom we have called upon for data have, in every case, given us what they could. To these our thanks are due, but we especially wish to thank Mr. R. E. Danforth, the General Manager of the Public Service Railway Company of New Jersey, and his assistants, for the interest they have shown, the help given and the service data furnished which form the basis of many of the conclusions in this report.

The members of the Committee, who have been considering the interurban service in connection with train operation, desire to report progress and request that they be given more time to study this subject.

Respectfully submitted,

H. H. Adams, *Co-Chairman.*
W. H. Sawyer, *Co-Chairman.*
H. A. Benedict,
John Lindall,
F. J. Stevens,
P. N. Jones,
M. D. Kilbride,
R. A. Crume,
Joint Committee on Train Operation.

Discussion of Report of Committee on Train Operation

Mr. Rockwell:—I would like to ask Mr. Sawyer if the use of trailers is taken into consideration at dead end terminals.

MR. SAWYER:—The Committee did not take it into account to that extent. We did not provide in our financial column any money for loop terminals.

MR. ROCKWELL:—You also refer to a two-car train. I want to ask whether that is a motor car and a trailer?

MR. SAWYER:—In some cases it is a motor car and in others a trailer.

MR. ROCKWELL:—How does that affect the cost of operation?

MR. SAWYER:—In A-1, A-4 and A-5 cases, the second car was a motor car; in A-6 and A-7 the second car was a trailer car.

MR. ROCKWELL:—You do not recommend the use of trailers at dead end terminals, do you?

MR. SAWYER:—We do not here.

MR. J. Q. BROWN:—I would like to ask Mr. Sawyer whether or not there was any consideration given to equipping trailer cars with control apparatus alone; in other words, operating the motor car by means of control apparatus on the controller.

MR. SAWYER:—There was consideration given to that but the results are not shown in the report. There were so many cases that we could have taken up that we found it necessary to drop consideration of many of them.

MR. J. Q. BROWN:—That would eliminate the loop question entirely.

MR. JOHNSON:—The following table shows the number of passenger cars, both motor and trailer, operated by each of the four elevated railroads of Chicago:

	Metro-politan	North-western	South Side	Oak Park	Total
Motor cars	225	148	370	64	807
Trailer cars	262	200	30	123	615
Total	487	348	400	187	1422

All cars are equipped with multiple-unit control apparatus, the motor cars with the complete equipments and the trailer cars with train line cable and suitable connector receptacles. To eliminate some of the objections to trailer car operation, as mentioned by your Committee, and to increase the flexibil-

ity of trains both in the yards and on the road all the trailer cars on the South Side and 40 per cent of the trailer cars on the Metropolitan are equipped with motormen's cabs and controlling apparatus so that the train may be controlled from one of these cars just the same as from a motor car. Accordingly many of our trains have a "control coach," as we call it, on the head end during the entire run and many other trains operating into stub terminals have a "control coach" on the head end one trip and a motor car the next trip. This arrangement has worked out entirely satisfactory and we are now starting to equip some of the trailer cars on the Northwestern line with cabs and controlling apparatus.

The trains as operated on the four elevated railroads vary from two to five cars per train, and the proportion of motor cars and trailers in a given size train varies considerably. On the South Side practically all cars are motor cars, as there are only thirty trailers out of 400 cars. This is an ideal condition from an operating standpoint as every car is a self-contained unit capable of taking care of itself. Considering that each car is equipped with the same capacity of motors in horsepower per ton of weight, the acceleration and speed of a five-car train will be just as fast as that of a two-car train.

The motor cars on the Metropolitan, Northwestern and Oak Park are equipped with motors of practically the same capacity, but the number of motor cars per train varies as follows:

	2-car train		3-car train		4-car train		5-car train	
	Composed	Horsepower per ton Lt. Wt.	Composed	Horsepower per ton Lt. Wt.	Composed	Horsepower per ton Lt. Wt.	Composed	Horsepower per ton Lt. Wt.
Metropolitan....	1 M. & 1 T.	6.3	2 M. & 1 T.	7.5	2 M. & 2 T.	6.3	2 M. & 3 T.	5.4
Northwestern...	1 M. & 1 T.	6.3	1 M. & 2 T.	4.5	2 M. & 2 T.	6.3	2 M. & 3 T.	5.4
			or					
			2 M. & 1 T.	7.5				
Oak Park.....	1 M. & 1 T.	6.3	1 M. & 2 T.	4.5	1 M. & 3 T.	4.0		
					or			
					2 M. & 2 T.	6.7		

From the above table we see that the motor capacity in horsepower per ton of train in the case of the three-car trains on the Metropolitan is 87½ per cent greater than in the case of the four-car Oak Park train with one motor car. With the equipments protected by a current limiting device the acceleration of the five-car Metropolitan and Northwestern trains and four-car Oak Park trains with one motor car is slower than the acceleration of the shorter trains which are operated during the non-rush hour periods.

Your Committee says that the selection of the type of equipment to be used depends upon local conditions. The cheaper train involving the trailer may not be applicable to all conditions, and the more flexible multiple-unit train would warrant its installation in the more extreme congested conditions. A study of the operating conditions on the elevated railroads of Chicago discloses a heavy, but short rush-hour period morning and evening which demands approximately four times the amount of equipment used during the middle of the day. Under these conditions the heavy investment and higher maintenance cost for all motor cars is not considered justifiable. On the other hand with the locomotive system and trains varying from two to five cars in length, the movement of trains is considerably slowed up during the rush hours at the very time it is desirable to get them over the road as quickly as possible. After a careful study of the operating conditions on the elevated railroads as they exist to-day, we believe that a combination of approximately equal numbers of motor cars and trailer cars equipped with cabs and controlling apparatus is the most economical and satisfactory.

Mr. McMillan:—The remarks of the gentleman seem to agree with our experience in Los Angeles. The plan he has stated is the plan that we have been following a good many years and we have found it very flexible and profitable.

Mr. J. Q. Brown:—I would also like to remark that we have been operating train service in that way about nine years. The rating of motors in a train is about as follows: At no time shall a train be made up of less than 12 hp. per ton. We operate trains from two to ten cars each and 575 trains

a day in and out of one terminal. Every twenty minutes we have a headway out of that terminal of about three-quarters of a minute, which connects with a line of steamers from San Francisco. That service, having control cars wired with all control apparatus, has proven absolutely satisfactory and very economical. It gives a flexibility in making up the trains that you can not obtain in any other possible way. It certainly should be included in the recommendations.

MR. ADAMS:—The last portion of this report pertains to city operation, particularly to two-car trains. The members of the Committee, who were to deal with the interurban side of it, have not reported; so we can confine this discussion to two-car trains and in congested city operation.

MR. MCMILLAN:—I would like to say for the gentleman's information it does not make any difference if it is city or interurban operation; the trains can run in the streets of the city the same as out in the country.

MR. J. Q. BROWN:— If we operate on a 45-second headway it makes no difference whether it is city or interurban service.

MR. ROCKWELL:—I want to ask whether it makes any difference in the leverage of the brakes, as between the trailer car and the motor car, which is much heavier, and whether or not it is not advisable to have a trailer car between the motor cars.

MR. JOHNSON:— We operate the trailer cars in any position of the train which may be the most convenient in making up trains in the yards. The trailer cars are braked with practically the same percentage as the motor cars. Practically all our motor cars have two motor equipments. In the majority of cars the two motors are on one truck. In that case the motor truck is braked up to a higher percentage than the trailer truck but the average percentage of the motor car is about the same as the trailer car.

MR. CRECELIUS:—In the operation of a double equipment, with the motor car in front and the trailer in the rear, considerable time is lost because of slowing the schedules. I wonder if that factor enters into the cost as given here.

MR. ADAMS:— Four to five per cent. slower schedule was taken where trailer cars were used, meaning that we had to have additional cars to take care of the traffic.

MR. CRECELIUS:—You mean that you had to increase your expense four to five per cent?

MR. ADAMS:—Yes, sir.

MR. BENEDICT:—The Committee confines itself to the study of city service with two-car train operation. Every individual road has to make its own study. You will note that the Committee members let themselves down easy by making the conditions and then saying if the conditions are met, the operation will be as represented. If you assume other conditions, you necessarily obtain different results, and, as stated, it is simply a question of studying your own local conditions. I will say that we have already started to study our local conditions in reference to two-car operation. We have, at the present time, equipped cars with multiple-unit control, both four motors and two motors, with the idea of testing, on our various lines, different traffic conditions, with two four-motor cars, or an eight-motor train, two cars, one with four motors, one with two, making a six-motor train, one with four motors on the one car and a trailer, and another two, with two motors on each car, with the idea of going over each of our lines and studying traffic conditions carefully with the various trains to decide, for obvious reasons, which type of train will fit conditions. With this data, we can determine which is better for all conditions.

MR. CRECELIUS:— Motor car and trail car operation is so important, at the present time, that I wish to have on the record the fact that in order to make it possible to get the schedule loss down to 4 or 5 per cent, a very high degree of maintenance of line voltage is required: the voltage throughout the line must be very high, and very steady. I simply wish to express here that the Committee's recommendation for trailer operation requires close and careful attention to trolley voltage otherwise the loss in schedule will be considerably more than 5 per cent; such has been my experience.

PRESIDENT SHANNAHAN:—Is there any further discussion? It might not be amiss to afford the representatives of some of the big electric companies the opportunity to comment on this report or criticise it if they desire.

MR. CASE:—Last year Mr. Franklin presented a paper on two-car train operation, with two motors on each car, and controllers large enough to handle the four motors. It is unfortunate that he is not present, as this paper was to be a continuation of that general subject. The manufacturing companies are not in a position to recommend a particular method of operating cars because there are so many different conditions of service. It is perfectly evident, from the opinions expressed here, that there is a great variety, and we stand ready to manufacture anything to suit the conditions put up to us. The ordinary cylinder controller, located on the platform, carries the total current for the motors. Such controllers have been developed to the highest possible standard and are much safer than they were a few years ago. At the same time, there is a remote possibility of a short circuit in the controller or among the wires entering it at the bottom, and this might cause a panic, resulting in injury to passengers. With a multiple unit control, where all heavy current carrying parts are located below the car floor, such a contingency is not possible and the indirect accident expense is eliminated. Of course this Committee has not gone into that subject. Some of the leading roads are now installing multiple-unit control without provision for running two cars in a train.

MR. ADAMS:—We are indebted to Mr. Jackson of the Public Service Railway, for some of the ammunition that is in this report. We would like to hear from him as to how this character of operation has affected their schedules in practice.

MR. JACKSON:—I would like to state, that at the time this test was taken, we only had one train in operation. That was a train of two cars, with two motors under each car. Our schedule speed was not affected to any great extent. A few competent trainmen were broken in to run the train, and when we tried it on the different lines, these trainmen went with the cars, which enabled us to obtain better results. We found

later, however, that for the operation of trains it is necessary to have trainmen thoroughly broken in. You are taking a man from a single car, giving him a new control to handle, and in addition to that you are doubling up the cars by having an extra car to handle during the rush hour. If he is not thoroughly trained he will not gauge his stops, and naturally he will not load his cars evenly. We were fortunate as our conditions enabled us to equalize the loading of both cars. In the test we found that taking the two cars together in a train, crossing at an intersection 118 ft. in length, the two-car train would cross over in 20.4 seconds, where it takes a single car an average of 16.9. On a train with 180 passengers, the interchange of passengers is 1.2 seconds per passenger, and on the unit car with 80 passengers is 1.7 seconds per passenger. This is an average record taken for one week. The average stops per mile on the train was 11, on the unit, 10. These stops with train operation were made where the streets in some sections are probably 200 ft. apart. I think the different companies in time, by getting together with the various municipal authorities can establish stops in the rush hours, whereby the schedule speed can be maintained with trains just the same as it can be with a single car, provided both cars are live cars. I do not think trailer operation is a thing that can be worked on all properties.

(On motion, moved and seconded, the report was accepted and placed on file.)

MR. CHOATE:— I believe that the excellent reports presented this morning by the Committees considering the matters of Block Signals and Train Operation deserve something more than passing recognition at our hands and I, therefore, propose that a vote of thanks be extended to the members of both Committees, as well as to the gentlemen who by their discussion of these subjects, have made this meeting so successful.

(Being duly seconded, the motion was unanimously adopted.)

(On motion, duly seconded, the meeting then adjourned.)

WEDNESDAY MORNING SESSION

OCTOBER 9, 1912

The meeting was called to order by President Ackerman at 10:00 a. m. in the Brown Room of the Saddle and Sirloin Club.

PRESIDENT ACKERMAN:— The first order of business this morning is the report of the Committee on Buildings and Structures, and as the Chairman and the Vice-Chairman of that Committee are not present, I will call upon Mr. Schreiber to present the report.

MR. SCHREIBER:— I want to explain first how I was delegated to present the report. I received a letter from Mr. Pegram, Chairman of the Committee on Buildings and Structures, asking that I read the report and make certain suggestions for continuing the work.

As Mr. Pegram explains, the paper was not sent out to you in advance, as were other reports, on account of the fact that it was not received by the Secretary in time to be set in type. The paper is here now and has been distributed with the other reports. With your permission, I will defer reading the report and make a few remarks in the hopes of bringing out a full discussion on the important subjects that have been considered.

For the first topic — General Specifications and Form of Contract for Railway Structures,— we have a proposed form in the appendices submitted by the Committee. This seems to be a very appropriate topic as there has always been considerable misunderstanding between the engineer and the contractor on construction work. Of late years an earnest effort has been made to produce specifications that would be mutually satisfactory to the owner and contractor by a number of technical organizations. The American Railway Engineering Association has made some important

investigations along this line and I presume the Committee has familiarized itself with the proceedings of that Association. Although the specifications submitted here in the appendices seem a very good form, no definite recommendations have been made and I trust that the members who have anything to add will not hesitate to speak, as it will be useful for next year's Committee.

For the second topic — Review of Modern Car House Construction — I am sorry to note that the Committee in its deliberations were not able to sufficiently consider the subject and make a report upon it. In 1907 at Atlantic City we had a committee report on this important topic and I apprehend it can be safely said that the recommendations of that Committee have since stood out as the best practice. It would be interesting, however, to review those recommendations and see what suggestions could now be made that would be desirable as actually found by practice in the field. The 1907 report recommended generally two types of structures: concrete or fireproof throughout; and concrete brick foundation walls, pits and floors with mill construction roof, also liberal pit area and continuous operation of cars. At that time it was generally the opinion among railway engineers that a few years would show practically standardization of the fireproof construction. Actual experience has not altogether substantiated these conclusions. We still have many holding on to the brick and concrete car house with mill construction roof; this is especially the case where the risk is sprinkled throughout to protect the contents as well as the buildings, and insurance interests have not discriminated in rates.

I think we should hear from a number who are present at this meeting about modern car house construction. There are so many details regarding which you will find practical railway men with quite different ideas. There is the question of pit construction. Is it necessary to have the pit track 50 per cent. or 75 per cent. of the operating car house track? Whether we ought to have solid or open pits? Should the

space between tracks be paved solid between rails at the same elevation or at a lower elevation than the top of the rail; or should the space between tracks be closed in solid or paved only in the middle with an open space adjoining the rail? Then again, we have the question of proper doors,— rolling or sliding doors,— also how far should the railway company go for proper facilities for offices and men's quarters, and so on. I could mention any number of details upon which a disagreement for proper construction no doubt could be easily found. I want to invite you all to a full free discussion on topic No. 2 — Review of Modern Car House Construction.

The third subject we have before us deals with proposed waiting rooms and shelters for electric railways. The Committee has made a complete report on this subject which speaks for itself. With your permission I will abstract the Committee's report.

REPORT OF THE COMMITTEE ON BUILDINGS AND STRUCTURES

To the American Electric Railway Engineering Association:

GENTLEMEN.—The following subjects were referred to your Committee by the Executive Committee of the Engineering Association, and at the first meeting of the Committee the various subjects were allotted to subcommittees as noted:

1. General Specifications and Form of Contract for Railway Structures. Messrs. Bronsdon, Weston and Harvie.

2. Review of Modern Car House Construction. Messrs. Low, Fiske and Pegram.

3. Proper Waiting Rooms and Shelters for Electric Railways. Messrs. Knight, Dougan and Young.

Owing to the late date at which the organization of the Committee was completed, it was impossible to prepare a formal report. We, however, present for the consideration of the Association a set of recommendations for proper waiting rooms and shelters for electric railways, prepared by Messrs. Knight, Young and Dougan, and a form of contract and bond, drawn up by Mr. Bronsdon. To this is added the comments of the various members of the committee to whom these papers have been presented.

Respectfully submitted,

GEORGE H. PEGRAM, *Chairman.*
F. F. LOW, *Vice-Chairman.*
GEORGE WESTON,
HENRY A. FISKE,
W. T. DOUGAN,
C. G. YOUNG,
D. G. KNIGHT,
W. J. HARVIE,
M. H. BRONSDON,
Committee on Buildings and Structures.

APPENDIX A

GENERAL SPECIFICATIONS AND FORM OF CONTRACT FOR RAILWAY STRUCTURES

Prepared by Messrs. Bronsdon, Weston and Harvie.

SPECIFICATIONS FOR LABOR AND MATERIAL TO BE USED IN THE CONSTRUCTION OF A BUILDING FOR A ——— HOUSE AT ———.

For the A. B. C. Street Railway Company

DEFINITION OF TERMS:

1. Whenever the word "Company" is used in these specifications, the same shall be understood to mean the A. B. C. Street Railway Company.

2. Whenever the word "Engineer" is used, it shall be understood to refer to an Engineer appointed by the Company, or his successor in that office, or the Engineer's assistant, limited in authority by the particular duty to which he may be assigned.

3. Whenever the word "Contractor" is used, the same shall be understood to mean the party or parties to whom the contract is awarded for the herein specified work.

LIABILITY:

4. The Company shall not in any manner be held responsible or accountable for any loss or damages which may happen to the work or any part thereof, nor for any injury to any employee or any other person.

5. The Contractor shall have control of the premises, works, ways and machinery for the purpose of guarding against accident or injury to employees or the public, and shall assume all responsibility for damage or accident to any person or property occurring by reason of any act of negligence of himself or employees, and shall hold the Company harmless for any loss or liability growing out of any injury or accident in connection with the work, and from all costs, attorneys' fees and expenses of every description in connection therewith; and, in case suits or other proceedings are brought against the Company to enforce any claims on liens including suits or petitions to enforce mechanics' liens for material, or any proceedings of like nature, the Contractor shall assume the defence thereof.

MATERIAL AND LABOR:

6. All material used in the work shall be of the very best of its kind for the use intended, and shall be subject to inspection by the Engineer, who shall have the right to reject material worked or unworked which is defective or not in accordance with the plans

and specifications, and the Contractor shall not be entitled to receive pay for labor used in the work so rejected by the Engineer, who may remove the same forthwith at the Contractor's expense.

SUB-CONTRACTING:

7. No sub-letting will be allowed unless agreed to in writing by the Company.

DEPORTMENT OF EMPLOYEES:

8. It is understood and agreed that the work shall be under the supervision (but not control) of the Engineer, and according to his instructions in all matters pertaining to the results required by the contract, but not as to the manner by which such results are to be accomplished. Foremen and workmen, the results of whose supervision or work are not satisfactory to the Engineer, shall be discharged at his request.

QUESTION OF MEANING:

9. Any question arising as to the intent or meaning of these plans and specifications shall be decided by the Engineer, whose decision shall be final and binding upon both the Company and the Contractor.

EXTRAS:

10. Any work or labor performed or expenses incurred other than what is required by these specifications, but which must be done or defrayed to fulfil the requirements of a city ordinance, or any other rule, regulation or law whatever of the city ordinance, or any other rule, regulation or law whatever of the city or public authorities, shall be performed and borne by the Contractor, and he shall have no claim for such work, labor or expense against the Company.

DELIVERY OF MATERIAL:

11. The Contractor shall be responsible for all cartage and freight, and for the handling and carriage of all materials and tools not otherwise provided for in these specifications, and the whole risk of any damage or loss, that may be suffered during transportation, carriage or handling of said materials and tools is hereby assumed by the Contractor. The tools and materials, as they are hauled to their destination shall be delivered and arranged in such order and location as the Engineer may direct, and shall be placed out of the way of travel and stacked in such manner as will avoid obstructing cross streets, driveways, private or other entrances, and, in case gutters and other water channels are blocked up, said Contractor must provide a way for the free flow of water so stopped.

PROTECTION:

12. All work done or materials furnished must be to the satisfaction of the Engineer in charge, and are subject to said Engineer's acceptance and his inspection and direction at all times, except that the Contractor shall have full authority as to the measures necessary for the protection of employees or the public against injury to their person or property.

NIGHT AND SUNDAY WORK:

13. Work or labor required by the Engineer to be performed on Sundays, nights, or holidays, shall be classed and treated as ordinary work and labor, and the Contractor shall receive the same pay for work performed on said days and nights as he is entitled to under the within contract, it being expressly agreed and understood that the said Contractor shall make no additional charge for the same, provided that said Sunday, night or holiday work is necessary to complete the building within the time specified in the contract.

14. The Contractor must maintain sufficient lights on the material used by him in the work, and must keep said lights burning from sunset to sunrise, and provide such watchmen as the safety of the public may demand or require; and the Contractor must provide for his material and work so as to comply with and fulfill all the requirements of the city ordinances and all municipal rules and regulations, or any other public laws which are now in force or which shall be passed or enacted.

ACCIDENTS:

15. In the case of any accidents the Contractor shall give immediate notice to the Company.

VIOLATION OF CONTRACT:

16. In case of the insolvency of the Contractor, or if the Contractor shall be declared bankrupt or make assignment for the benefit of creditors, the Engineer, after notice to the Contractor or his representatives, shall have the right at his option to terminate the contract. And, upon the happening of any of the aforesaid, the Company shall have full possession of the work and control of the same in process of construction and already constructed in its then condition and may have the work completed by other parties, charging the Contractor or his representatives with any and all expenses of the same; it being expressly agreed and understood that in any event the Company shall be entitled to compensation for all damage suffered by reason of such insolvency, bankruptcy, or assignment for the benefit of creditors.

INTENT OF SPECIFICATIONS:

17. The plans and specifications are intended to be explanatory of each other, but should any discrepancy appear or any misunderstanding arise as to the true intent or meaning of anything contained in either, the explanation and decision of the Engineer shall be final and binding, and all directions or explanations required or necessary to complete any of the provisions of these specifications to give them due effect shall be given by the Engineer. Correction of errors or omissions in drawings or specifications may be made by the Engineer.

ALTERATIONS OF PLANS AND SPECIFICATIONS:

18. Should the Engineer desire to make any changes, alterations, deviations in, or additions, to or from said plans or specifications, or should he desire to fill any omission therein, he shall have the right to do so, and the cost of such changes shall be added to or deducted from the contract price at a fair and reasonable valuation which must be agreed to in writing by the Engineer and Contractor before the changes are made; and, if no agreement can be made as to the cost of said changes, the Engineer shall have the right to take possession of the work subject to said alterations, changes, deviations or omissions and have the work completed by other parties.

DAMAGE TO WORK OR MATERIALS:

19. The Company shall not in any manner be answerable or accountable for any loss or damage that may happen to the work or any part thereof, or for any material used in the finishing or completion of the same; and it is expressly agreed and understood that said work in all stages of construction and until its completion and acceptance by the Engineer, is wholly at the risk of the Contractor, and that if the work done by the Contractor is destroyed by fire, flood, storm, tempest, trespassers, or any other cause, the said Contractor shall rebuild, replace, and reinstall said work and materials at his own cost and expense.

PLANS:

20. The extent of the work is illustrated by a set of general plans of the floors, basement and elevation and constructional drawings, and the contract is to embrace such work as is illustrated by these various drawings and plans, and it is expressly agreed and understood that the specifications and drawings set forth are intended to co-operate and agree, and that they are to be interpreted so that any work or materials exhibited in the plans and not mentioned in the specifications, or vice versa, shall be done or furnished as if set forth in both, said work to be executed in a thorough manner and of materials best fitted for the required purpose.

All work indicated on drawings, the dimensions of which are not figured, is to be accurately produced according to the scale measure to which they are drawn; but when figures are given which disagree with the scale measure, the figures and not the scale measure shall govern.

The Contractor, by the execution of the contract for the work and materials herein called for, admits that he has examined the plans and specifications and that they are sufficient for their intended purposes, and that they can be carried out without extra work to their full performance and completion, for which he becomes hereby fully responsible.

LINES AND BATTERS:

21. The Contractor is to assist in establishing all lines for laying out the building and is to furnish material for and put up all necessary batters and stakes that may be required by the Engineer, and is to be responsible for maintaining the position of the same during the construction of the building and erection of the exterior walls until the latter are built two (2) feet above finished grade.

SOUNDINGS AND PUMPING:

22. The Contractor may make necessary borings and soundings in order to determine the character of the formation of the subsoil or stone, and to determine also whether water will be encountered. The Contractor is to do all pumping required to complete his work as called for under the contract.

EXCAVATION AND GRADING:

23. The entire building site to be cleared of all sod and loam and excavated to necessary depths for the construction of all foundations, footings, etc., as called for by plans, and if it should be found necessary to go to a greater depth to secure a firm footing, the Contractor shall receive a price per cubic yard for excavation and concrete work as may be mutually agreed upon before the work is begun.

Contractor shall furnish all necessary material required for bringing site enclosed by building to a proper grade and shall remove all surplus material from the premises.

Building sand and gravel, if found on the premises, and approved by the Engineer, may be used by the Contractor without charge.

MATERIALS:

24. Aggregate for concrete foundations to be of good, clean, strong, broken stone one-half to two-inch size, or good, clean, screened gravel.

Sand to be clean, coarse and sharp. Cement to be of Portland brand, such as Whitehall, Atlas, Alpha or Universal, and shall be delivered and kept in good condition until wanted for use.

Lime must be in the lump, freshly burned, and kept dry.

WATER:

25. The Contractor shall make application for the installation of the city water service, and shall also arrange for the use and the payment of same as required for building purposes.

FOUNDATIONS:

26. Footings, foundation walls and piers to be of Portland cement concrete composed of one (1) part by volume of Portland cement, three (3) parts sand and six (6) parts broken stone or screened gravel, one-half to two-inch size.

Method of mixing concrete to be optional with the Contractor, but whatever method is used shall insure the most thorough mixing of all the ingredients. If platform is used it shall be made perfectly tight, and concrete shall be deposited immediately and in such a manner as not to separate the stone from the mortar, and it is to be thoroughly worked down into places so as to prevent any voids being formed.

If concrete is deposited against the surface already set, such surface shall be thoroughly cleaned and then coated with thick cement grout.

BRICK WORK:

27. All brick to be of the best quality merchantable hard brick, burnt entirely through, regular and uniform in size and after being well wetted to be laid in lime and cement mortar, composed of one part Portland cement, one part lime paste and six parts sharp sand. All bricks for exterior surfaces are to be culled on the job for color, quality and form.

All brick of improper quality and all bats of less than one-half size shall be removed from the premises and no brick shall be laid until properly inspected after being culled.

Brickwork for outside surfaces to be "jointed or ruled" with a round-edge tool. Brickwork of interior surfaces to be struck and pointed with a trowel. All brick are to be completely bedded in mortar, under the bottom, on the sides and ends at one operation. All outside surfaces of brickwork are to be brushed and cleaned after completion and then washed with diluted muriatic acid and water, so as to effectually clean the same and bring out uniformity of color, and when dry the entire outside surface to be given one heavy coat of raw linseed oil.

Samples of brick are to be submitted with bids and are to be labeled and numbered.

TIMBER:

28. Wherever hard pine is used as timber for any purpose, it shall be subject to "Merchantable Inspection," in accordance with the Interstate rules of "Classification and Inspection of Yellow Pine Lumber" of the Yellow Pine Exchange, New York.

STONE WORK:

29. Stone, which is to be used for window sills, thresholds, copings, or for any other purposes, to be uniform in color, grain and quality; free from light or dark spots, stains or any defects which may tend to impair its strength, durability or general good appearance.

Wherever rock-face stone is used, exposed surfaces shall not vary more than one-half inch from a straight line. Stone thresholds to have lugs and wash with top and ends pointed and front face of six-cut work. All stone window sills, thresholds or coping to have one-inch overhang.

CONTRACT

THIS AGREEMENT made this ..... day of ..... by and between ..... of ....., hereinafter called the "Contractor," and the A. B. C. Street Railway Company, of ....., a Corporation existing under the laws of the State of ....., hereinafter called the "Company."

WITNESSETH, That said Contractor hereby covenants and agrees to and with said Company that he will, at his own cost and expense and in strict conformity to the hereto annexed specifications, furnish all tools, appliances and materials (except such materials as are to be furnished by the Company, as expressly provided for by the specifications hereto annexed) and labor necessary and proper for the purpose of constructing in a good, substantial and workmanlike manner the ..... for a ..... on the property of the Company situated on ..... in the City of ..... in the County of ..... and State of .....

And the said Contractor further agrees to and with the said Company that he will construct this ..... strictly pursuant to and in conformity with the hereto annexed specifications and general plans, which are signed by the Contractor, which specifications and plans are hereby made a part of this agreement, to be equally binding with the other terms of the contract; and said Contractor agrees to be bound by each and every one of the provisions of the said specifications and general plans according to their true intent and meaning, and in the same manner as if expressly set forth in both.

And said Contractor agrees to file with the Treasurer of the Company a bond in such form and in such surety or sureties as will indemnify the Company against accidents, liens or losses of any nature, which bond shall be an amount equal to seventy-five (75) per cent. of the price named below.

And it is expressly agreed and understood that in addition to said bond the Company may reserve from the contract price such amount as will indemnify the Company in case any claims are made against it such as are recited in clause five (5) of the annexed specifications, the amount to be withheld from the contract price to be at and within the discretion of the Manager of the Company.

And said Contractor agrees to commence work immediately upon the execution of the contract and to complete same on or before ..... (.....), and to have the ..... ready to be operated as a ....., and in case of failure to complete the work on the date mentioned, to pay to said Company ..... (.....) for each and every day such completion is delayed beyond the time specified; the said payment to be made not as a forfeit, but as liquidated damages for such inconvenience or loss as the said Company may suffer.

For any delay caused by a strike or lockout among workmen employed upon this work, additional time equivalent to such delay shall be allowed for the completion of this contract, provided such strike or lockout is not caused by any action of the Contractor.

And the said Company in consideration of the premises, hereby agrees to pay to said Contractor the sum of ..... (.....) in full payment for the above work, including all charges for labor, material, tools and appliances, and all costs and charges whatsoever, payments to be made, less ten (10) per cent. on or before the fifteenth (15th) day of each calendar month on all work and materials furnished during the preceding month, as evidenced by an estimate and certificate which is to be made and furnished by the Engineer on or about the fifth day of each calendar month. Upon the final completion of the work in a satisfactory manner, the Engineer shall furnish to the Contractor a certificate to that effect, and the remaining ten (10) per cent. shall be paid to the Contractor thirty (30) days thereafter. And it is expressly agreed that the liability of the Company for any payment whatever is dependent upon the Contractor obtaining from the Engineer a certificate reciting the amount to be paid to said Contractor and stating that the work performed and materials furnished by the Contractor are satisfactory to said Engineer. And it is further agreed and expressly understood that such a certificate shall be a condition precedent of any right whatsoever of the Contractor to receive, demand or claim any money or other compensation under this agreement, and a condition precedent to any liability on the part of the Company to the Contractor under or on account of this contract, or for any labor or materials furnished in the connection therewith.

In witness whereof the said Contractor has hereunto set his hand and seal, and the said Company have caused this agreement to be

signed and its corporate seal to be hereto affixed by its ....., thereunto duly authorized, on the day and year first above written. In presence of:

.....

.....

CONTRACTOR.

THE A. B. C. STREET RAILWAY CO.

Witness

By .....

Witness

.....

.....

KNOW ALL MEN BY THESE PRESENTS THAT WE or I ..... and ....., copartners, doing business as ..... of (City) in the State of ....., as Principals, and hereinafter called the Principals, and ....., a corporation having its principal office at ....., (State) ..... as Surety, are held and firmly bound to the ..... hereinafter called the Obligee, to the full and just sum of ....., ($.....) dollars, lawful money of the United States, to the payment of which sum well and truly to be made, the Principals and Surety hereby bind themselves, their executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

Signed, sealed and delivered this ..... day of ..... A. D. .....

The condition of this bond is such that

WHEREAS the Principals have entered into a written contract with the Obligee of even date herewith for the construction and erection of a certain ..... in the city of ..... (State) .....

NOW, THEREFORE, if the above bounden Principals shall in every respect carry out and perform their part of said contract and shall indemnify and save harmless the Obligee, its successors, and assigns from and against all accidents, liens and losses of every nature, and from all loss, cost, damage or expense arising from or growing out of the same, then this obligation shall be void, otherwise of full force and effect.

IN WITNESS WHEREOF the parties have hereunto set their hands and seals, the said ..... day of ..... A. D. .....

Signed, sealed and delivered
in the presence of

.....

.....

.....

APPENDIX B

PROPER WAITING ROOMS AND SHELTERS FOR ELECTRIC RAILWAYS

Prepared by Messrs. Knight, Dougan and Young

Recommendations

Waiting rooms and shelters for electric railways are rapidly becoming very pertinent questions in connection with the operation of trolley lines. The public authorities are continually urging more facilities and where comparatively a few waiting rooms, outside of permanent stops on the interurban, were required a few years ago, a demand for the waiting room on the urban railway is not uncommon.

Attention is called to the paper on waiting rooms and shelters by Mr. D. G. Knight. Below are the recommendations and conclusions of your Committee:

(1) On account of local conditions and policy of different properties, no attempt has been made to standardize the construction of shelters and waiting rooms.

(2) Where only waiting places for patrons are required, as is the case at the interurban stop, the semi-closed shelter is recommended.

(3) If it is necessary to maintain toilets and it is not practical to combine a news stand or store in connection with the shelter, non-freezing toilets are satisfactory.

(4) Where isolated waiting shelters are required and it is necessary to provide toilet facilities, a shelter should be provided that includes a news stand or store. The proprietor of the store may be engaged to look after the waiting room and appurtenances in return for privileges.

(5) Waiting rooms in connection with car houses or terminals was covered in report of Committee on Buildings and Structures of 1910, and has not been given consideration.

PROPER WAITING ROOMS AND SHELTERS FOR ELECTRIC RAILWAYS

By D. G. Knight

Waiting rooms and shelters are rapidly becoming very pertinent problems in connection with the electric railway. The public and authorities are continually urging the Companies for more facilities, and where comparatively few waiting rooms were required outside of permanent stops and stations on the interurban a few years ago, it is not uncommon to have requests for shelters on the urban property at junctions of lines or at the terminus of a route. It is true that requests for facilities of the above nature are often absurd and not worthy of consideration, but on the other hand, there may

be good reasons for the waiting room. Again, in some instances it is necessary to have protection and conveniences for the Company's employees at the end of a long line at a considerable distance from the car house which may be advantageously combined with a shelter for the public.

Generally we may divide waiting rooms or shelters in the following classes:

(1) Open or semi-closed shelters.
(2) Closed shelter or combination of the open and closed shelter.
(3) Closed shelter without heat, but equipped with non-freezing toilets.
(4) Closed shelter with toilets and heat.
(5) Waiting room in connection with news stand or store.
(6) Waiting room at the station or terminal.

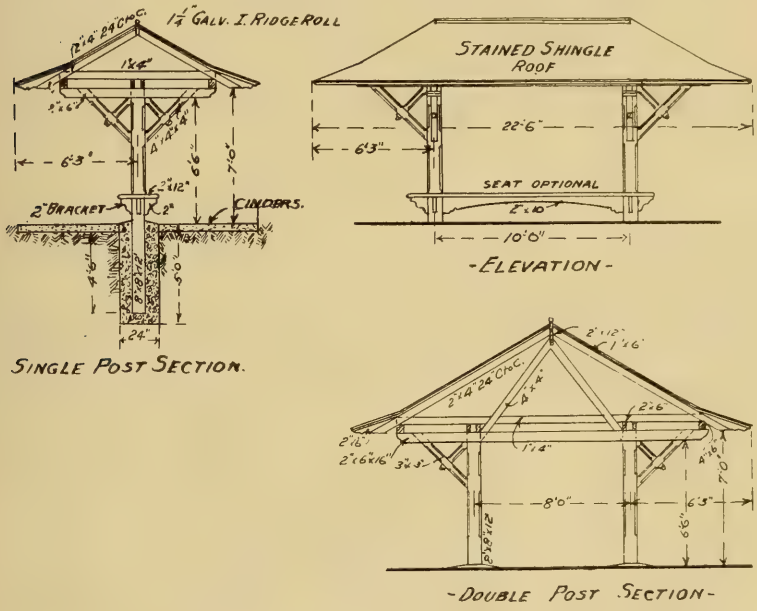


FIG. 1. SHOWING MODERN TYPE OF OPEN SHELTER.

In the first class we have a very large variety, varying from the most modest sort of a shed to the more substantial station with steel frame and tile roof, or constructed of concrete with permanent floors.

More modern types of waiting rooms are shown in Figs. 1 and 2. It is often more economical for a Company to build these small

sheds at its own shops and ship to the site on a work car. The foundation may be of timber or concrete and floors ordinarily laid with screenings or ashes.

The semi-closed type of shed where there is not supervision, is popular, because you have two conditions to meet: *first,* there

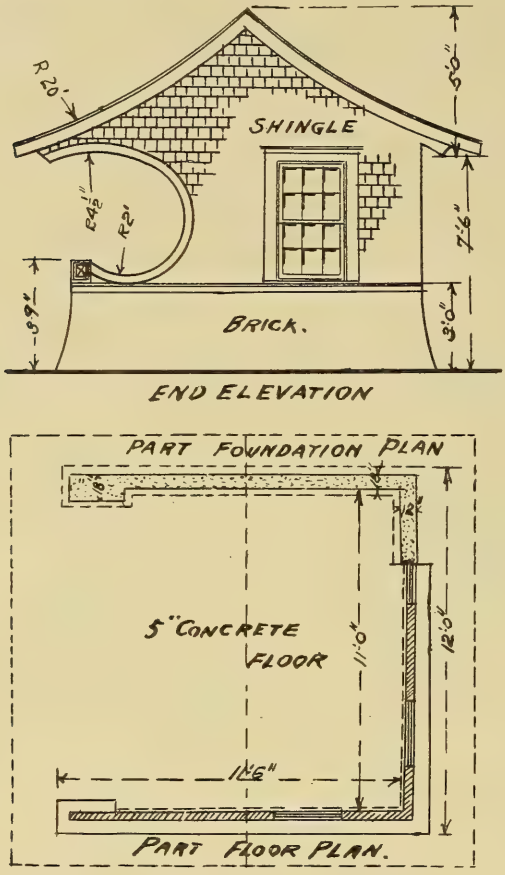


Fig. 2. Showing Modern Type of Semi-Closed Shelter.

should be enough enclosure to afford protection against the rain, and *second,* it is not desirable to afford hiding place for vagrants who are always prone to commit nuisance.

The location of the waiting room may be such that it is under constant surveillance, and Fig. 3 is an example of a combination of the open and closed waiting room of class two. Ordinarily, the

open shed portion is used by the patrons of the trolley, while during very inclement weather a protection is afforded by the closed portion of the building. Again, you may close the waiting room with glass, as in Fig. 4, which is the shelter on the one of the lines of the Public Service Railway Company at Morsemere, New Jersey. It is interesting to note that this design does not materially differ from Fig. 5, which is a waiting room on a foreign urban railway at

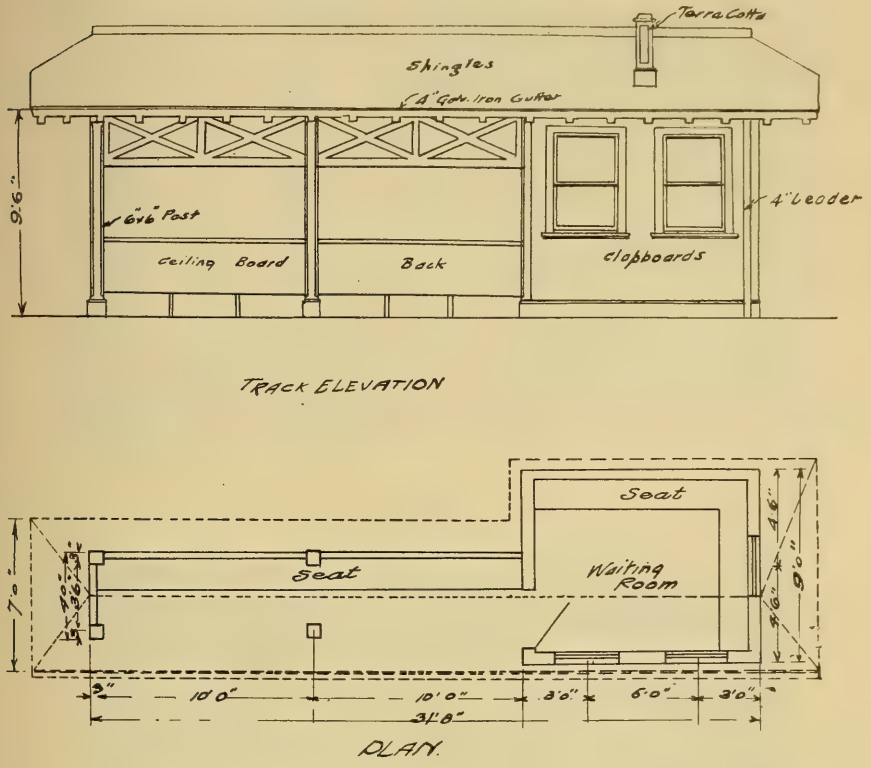


FIG. 3. SHOWING COMBINATION OF OPEN AND CLOSED WAITING ROOM.

Vienna. Ordinarily, there is much objection to the glass surface in this plan on account of the care and cost of maintenance.

When toilet facilities are required the waiting room begins to be a more serious consideration. Generally, these conveniences carry with them heating, lighting, supervision and higher cost of maintenance. A very economical arrangement is shown in Fig. 6. This waiting room is supplied with the non-freezing toilet. This arrangement does not require any heating or constant supervision and is often desirable at such locations as at the end of a trolley line, where it may be used by both the Company's employees and

patrons. The non-freezing toilet is an arrangement so that no water remains in exposed piping. The device is automatic so that raising the seat fills with water a flush tank overhead, and lowering seat releases the valve that permits the flushing of the bowl.

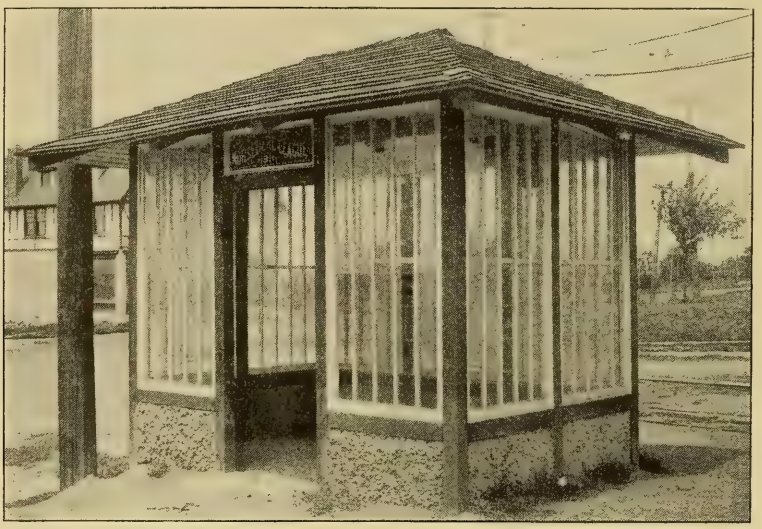


FIG. 4. SHOWING SHELTER ENCLOSED WITH GLASS ON LINES OF PUBLIC SERVICE RAILWAY CO.

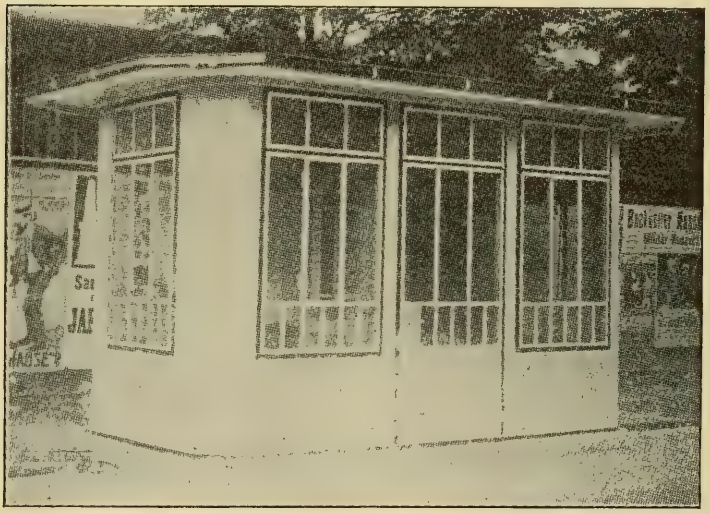


FIG. 5. SHOWING SHELTER AS USED ON URBAN LINES IN VIENNA.

Sometimes isolated waiting rooms are required that must be fitted up with toilets, heating and lighting, but this is so rare an occurrence that its discussion is omitted. If toilet facilities are re-

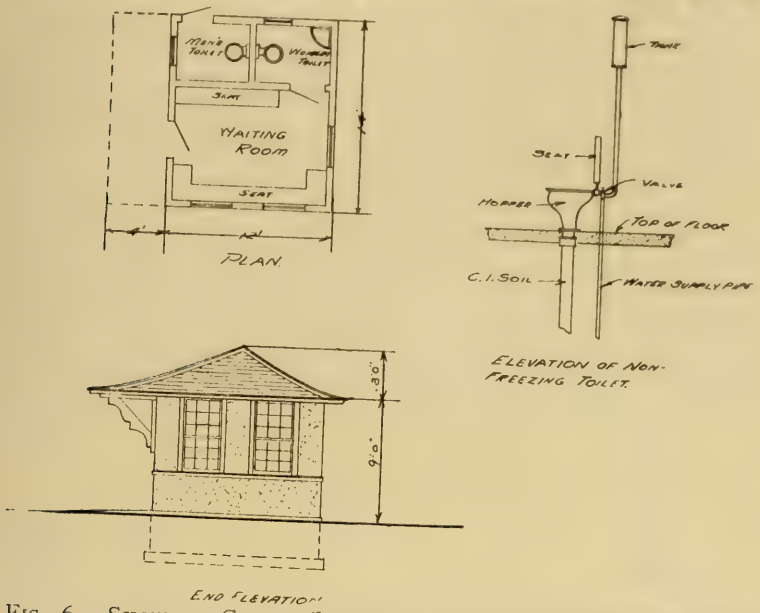


FIG. 6. SHOWING CLOSED SHELTER EQUIPPED WITH NON-FREEZING TOILETS.

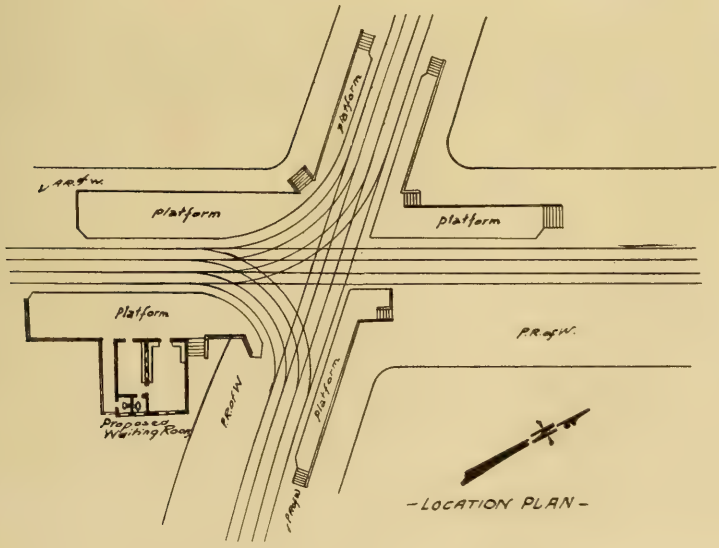
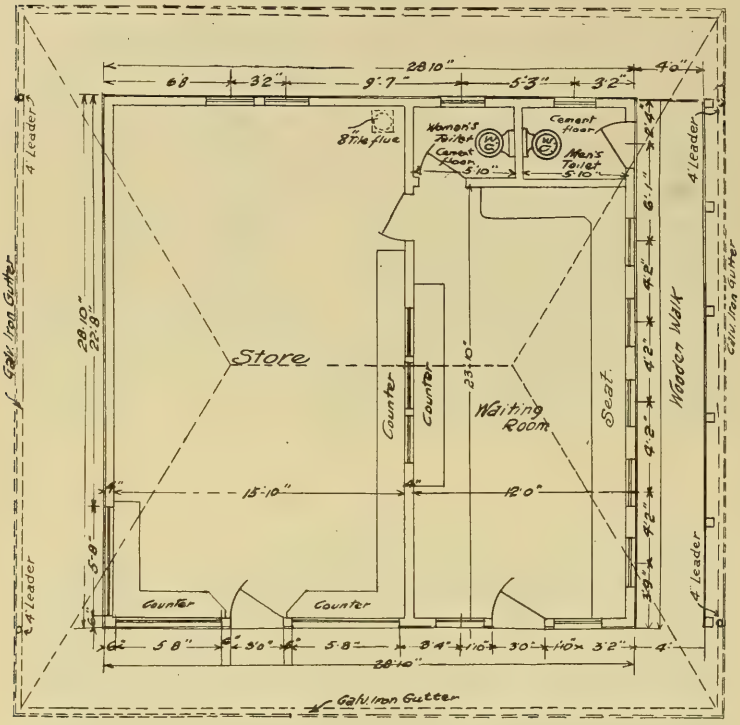


FIG. 7. SHOWING LAYOUT OF WAITING ROOM.

quired it is generally best and cheapest to make the waiting room large enough to secure a store space that may be a source of revenue, or at least furnish funds to meet the supervision and upkeep of the waiting room. This scheme is proving very satisfactory and recently is being advocated by many railroad interests.

Figs. 7 and 8 show the layout of a waiting room 12 ft. by 24 ft. with two toilets and a store space 16 ft. by 24 ft. The cost of the



GROUND PLAN

FIG. 8. SHOWING FLOOR PLAN OF WAITING ROOM WITH STORE.

complete building was $1500, and the store is rented by a vendor, who sells fruit, candies and newspapers, at a nominal amount per year. In addition, the vendor looks after the waiting room, keeps it heated and in good operating and sanitary condition. Some such arrangement as just described, where it is necessary to prove facilities at an isolated waiting room, is certainly the most desirable plan that has yet been introduced to any great extent.

The room in connection with the station or terminal was covered

in a general way in report of Committee of 1910. Here the supervision may be had by the employees of the Company in connection with other duties. An illustration is shown in Fig. 9. The con-

FIG. 9. SHOWING WAITING ROOM WITH SUPERVISION UNDER EMPLOYEES OF COMPANY.

struction and design of such a waiting room varies a great deal, depending on the conditions, and each proposition should be separately studied and treated accordingly.

APPENDIX C

SUMMARY OF OPINIONS OF MEMBERS OF COMMITTEE ON BUILDINGS AND STRUCTURES IN REGARD TO REPORT ON SUBJECT OF "PROPER WAITING ROOMS AND SHELTERS FOR ELECTRIC RAILWAYS," ALSO IN REGARD TO PROPOSED CONTRACT AND BOND.

Mr. W. T. Dougan, Member. "Approved."

Mr. G. W. Weston, Member. Report on Proper Waiting Rooms Approved.

"On certain particular points I have the following suggestions to make: (Proposed Contract, Bond and Specifications.)

Form of contract, page 10, last paragraph, appears the following:

"..... which bond shall be an amount equal to seventy-five (75) per cent. of the price named below."

I believe that the amount of per cent. should be omitted, and that this sentence should read as follows:

"..... which bond shall be in amount equal to ..... per cent. of the price named below."

On page 11 in the eleventh line in the fourth paragraph preceding the word "certificate" should be introduced the word "final"; then the ninth line would read:

"..... engineer shall furnish to the Contractor a *final* certificate to that effect."

On the same page, beginning in the fourteenth line in the same paragraph appears the following:

"..... dependent upon the contractor obtaining from the engineer a certificate."

which should be changed to read:

"..... limited to the amount shown to be due the contractor by the engineer's certificate."

and then the sentence would read:

"..... and it is expressly agreed that the liability of the company for any payment whatever is limited to the amount shown to be due the contractor by the engineer's certificate reciting the amount to be paid to said contractor and

stating that the work performed and materials furnished by the contractor are satisfactory to said engineer."

Otherwise, this form of contract seems to be O. K.

Regarding the Specifications:

In Paragraph 2, page 4, I would recommend the following substitution:

"Whenever the word 'Engineer' is used it should be understood to refer to the engineer appointed by the company to supervise the work, or his duly authorized representative."

In Paragraph 8, page 5, the last six words: "Shall be discharged at his request," should be changed to read: "Shall be removed from the work."

In Paragraph 18, page 7, second line, the word "in," following "deviation" should be changed to the word "from"; and the words "or from," following the word "to," should be stricken out, making the second line read as follows:

".... alterations, deviations from, or additions, to said plans or Specifications."

With these changes I approve the form of contract, bond and Specifications.

Mr. Henry A. Fiske, Member. "Approved."

Mr. C. G. Young, Member. "I have approved these papers. However, I think that some of the provisions in the contract might be more explicit, as they could be construed to work a considerable hardship on the contractor."

Mr. M. H. Bronsdon, Member. "Approved."

"I believe that when a company requests bids upon any structure of any type, or for any purpose, that the bidders should be called upon to furnish a letter from a satisfactory bonding company, in which the bonding company offers to furnish the bond of the contractor, said bond to equal the amount of the contractor's price, whatever his price may be.

This, I think, is made necessary owing to the fact that occasionally unreliable contractors through influence bid upon work, sending in low prices and then, on account of their poor reputation, are unable to obtain a satisfactory bond.

"If they are called upon to submit with their bid a letter from a satisfactory bonding company, in which the bonding company offers to furnish a bond, should the bidder be successful, then the contract can be closed immediately without waiting for the bidder to obtain his bonds. The bidders are also saving the cost of obtaining the bond, or furnishing even a certified check, provided the above method is pursued."

Mr. George Pegram, Chairman. "I think this report is just what is wanted. I think the suggestion that the subject be carried over until 1913 is a very good one and should be incorporated in the Committee's Report."

Mr. D. G. Knight, Member. "Approved."

Mr. F. F. Low, Member. "Have been away — no time to analyze for criticism, but see nothing I would disapprove."

PRESIDENT ACKERMAN:— Gentlemen: The paper is now before you for discussion and I presume you will want to discuss it in the form in which it is presented, the first subject being — General Specifications and Form of Contract for Railway Structures. Has any gentleman anything to offer on this subject?

The report is now before you and undoubtedly there are many who have interesting ideas upon these subjects and we would like very much to hear from them in order that the matter may be of record and serve as a guide to the Committee in its work next year. If there are no gentlemen who wish to discuss the first subject, we invite discussion on either of the other subjects taken up by the Committee. The next subject is — Review of Modern Car House Construction.

Discussion of Report of Committee on Buildings and Structures

MR. HANNA:— The Committee has not made a report on the second subject, which is probably of more importance to most of us than the other subjects. We all have car houses, and some of us have waiting shelters and others have not. In the matter of car house design and construction I have been particularly interested for several years, having practically rebuilt the whole system of car houses on our road, and I would like to hear some discussion on that subject for my own benefit, at least. Mr. Schreiber has outlined the different points that have been brought up, first, the broad point as to whether the construction shall be mill construction or concrete. It is stated that, if the sprinkler system is installed, the insurance rates are the same on both forms of construction. That is a good point but we are interested in the protection against fire, whether or not it is taken care of by the insurance companies. Some of us carry our own insurance and are not particularly influenced by rates, but to me the advantage of fireproof concrete construction very much outweighs any considerable difference in cost.

My own experience with mill construction has been in connection with a power station and office building. This building was of the slow burning type, and our company was so unfortunate as to have it burned down completely in twenty minutes some years ago. If it had not been of the slow burning type, I do not know how much more quickly it would have burned down. It was a six-story building and covered a whole block. Since that time the mill type of construction has not appealed to us. Concrete construction will undoubtedly be more expensive, but when we consider the relative cost of the equipment put in the building, together with the cost of the building itself, it would seem that there is no question but that we should adopt the most perfect fireproof system of construction that is possible.

Another question is the use of a sprinkler system. The underwriters have required, in order to give any reduction in rates, a sprinkler system under the roof, and also aisle

sprinklers. That is one point the advantage of which I cannot understand. In a fireproof building, the only combustible matter in the building being the cars that are stored therein, the installation of a sprinkler system on a fireproof roof seems to me somewhat unnecessary. I would like to have some expression of opinion as to why that was called for and why an aisle sprinkler system is not all that is required. That sprinkler system should take care of any possible fire in the cars, which are the only combustible matter in the building.

Mr. Roberts:— We are engaged just now in the construction of a power house and shop and were very careful to investigate the best examples of construction to be found, and finally concluded that the best procedure would be to use brick, with finished tile interior, and a tile roof laid on cement.

In connection with the question of the method of constructing the paint shop, which was a very important one, because some time ago we had a valuable private car and some city cars burned in our paint shop. In this connection a baggage crew passed our shops at 6.33 A. M. and at 6.47 we had no paint shop or cars. We were anxious to provide the best possible form of construction and decided to put up tile walls, with a corrugated sheet iron roof, the wiring of the paint shop being strung on messenger wires. I do not think there is three feet of woodwork in the whole building. The only place where we have any wood at all is just at the front entrance, to prevent the possibility of a trolley pole leaving the wire and striking the girders of the roof. The lighting arrangement was so arranged that the circuits had to be cut in at the master painter's desk. On the outside of the paint shop there is a main lighting and trolley switch under lock and key, and as the foreman leaves the shops at night he cuts out the main line on the main trolley switch. When we had an inspection of the shops a little while ago by the insurance people, they practically threw up their hands and we received a very favorable consideration.

With regard to the construction of the waiting rooms given in the report, I think we have some very good ideas ex-

emplified here, but, so far as we are concerned, it would be hardly safe to erect anything like that. I am afraid we couldn't expend money enough to keep them in proper repair. We have put up buildings not quite so elaborate as these on sections of our road and have invariably found that the people did not appreciate that which was done for their comfort, individually and collectively. These buildings almost always were found to be in a state that was simply a disgrace to the community in which they were located. Only recently we left a waiting room something after the style of the one on page 358, that had been abandoned as a stop, in order that the people might have a shelter, and not long afterward we found that the building had been almost entirely destroyed; indeed then so little was left of it, that the other day when a man wanted to buy the bricks of the building I consented to allow him to have them for nothing if he would remove all of the debris. I hope, when such buildings as this are erected in New Jersey or New York, that better consideration will be had for them than on our system. This paper is exceedingly interesting to me just now, and there are some very valuable suggestions that are worthy of our consideration. The chief thing is, that we ought to discuss these things, for I am sure that we have a vast amount of information for you gentlemen and I think credit might be very freely given to the men who have written this pamphlet.

Mr. Griffith :— The gentleman who spoke about the car house being destroyed by fire did not say whether or not that car barn was equipped with a sprinkler system. I have not read this paper and I do not know whether or not the Committee has made any investigation in regard to differences in cost between a concrete car house and one of mill construction. I am rather inclined to favor the mill construction with a sprinkler system installed, not only the roof being sprinkled, but the sprinklers so located between the cars, that the water will be thrown inside of them. Building a concrete car house and storing it with inflammable material like our cars are built of, seems to me like building a concrete house and filling it with hay or furniture. I think it is quite as important to

have a sprinkler system installed in a concrete barn as in one of mill construction.

MR. HANNA:—Answering the last gentleman who spoke I will say the building that I spoke of was a combination power house and office building and a sprinkler system was not installed. I entirely agree with the gentleman in thinking that the aisle sprinkler system ought to be installed in all car houses, but I do not see that having inflammable matter to store, that we should store it in inflammable buildings. We have to store cars and they are made of material which burns. More than that, they have electric wires which are likely to cause fire, and a fireproof building I would think, would be the logical thing.

MR. PALMER:— I was a little sorry to see that first topic passed over without any discussion — that is, the recommendations for specifications and the form of contract for railway structures. As I read it over it appeared to me to be almost word for word, so as far as the specifications, and the form of contract and bond, were concerned to be the form of contract, bond and specifications that the Bay State Street Railway Company is using, and under which it has erected buildings and other structures at a cost of many hundreds of thousands of dollars. In the specifications, paragraphs 1 to 20, there are set out the general relations between the contractor and the company. Those, of course, are supplemented with the specifications which follow and other specifications which would follow in any particular case, as referring to the manner in which the building material is to be handled. It is a very important matter that a contract and specification which will stand the test of possible litigation be used, and it is my opinion that this comes very near being an iron clad form. It there is favor anywhere it is on the side of the company rather than on the side of the contractors.

As to the question of mill versus concrete construction entirely, I would like to inquire if any of the gentlemen have accurate information as to the difference, if any, in the insurance rates which are obtainable for each type.

MR. SCHREIBER:— I think I can answer Mr. Palmer's question. You must sprinkle both the fireproof building and the

semi-fireproof building, and the insurance interests up to this time have not given any advantage in rate, when you take into consideration the contents, on account of the construction. At least, that is the case in New Jersey, and is one of the things that has prevented more general use of the all fireproof and concrete construction. Of course, as long as it costs more to build the concrete car house and you do not get any advantage from an operating point of view it is difficult to get managements to adopt the concrete construction over mill construction. It may be well to explain there is very little difference in the first cost of either construction for short span roofs. For example, a two track bay of concrete or fire proof construction costs less than five per cent. more than one of semi-fireproof construction. Certainly in this case, even with the same insurance rates, the fireproof construction is preferable. It has been my experience, however, that for a three or four track span the concrete construction may add 20 per cent. to 30 per cent. to the first cost over the mill construction; that is, figuring that the same sprinkling equipment is required in both cases. In some locations the insurance interests do not require the roof sprinklers for the concrete roof, and in this case the cost of the roof installation of sprinklers is just that much in favor of the car house of all fireproof construction.

Mr. Rust:— We have a rather novel form of waiting station on our line. One of the industries on our tracks happens to be a sheet metal manufacturer, who makes pipes, cisterns, etc. As an advertising feature they proposed, about a year ago, to put one of their cisterns on our line and make it in the form of a waiting room. They used an ordinary cistern of galvanized iron and put a roof on it. It seems to be almost boy-proof, and so far nobody has been able to cut any holes in it. We like it so well that we are thinking of buying a number and erecting them for our outside stations.

Mr. Bedwell:— I have not had an opportunity to look over the paper presented here, and the only thing that I might comment on is the matter of sprinkling in the case of mill construction roofs over that of reinforced concrete. I

believe in the East, the insurance people have almost agreed to eliminate the roof sprinklers where there is a concrete roof.

MR. GEORGE:—I notice that in the general specifications the inspection of the lumber is to be governed by a definite recommended set of rules, which are generally recognized throughout the country as standard. In the case of cement, however, the specifications simply state that "The cement to be of Portland brand, such as Whitehall, Atlas, Alpha or Universal." Would it not be better to eliminate all reference to any particular make of cement and simply state that "The cement shall conform to the requirements of the Standard Specifications for Portland Cement of the American Society for Testing Materials, as adopted August 15th, 1908." This would eliminate any claim of partiality and would fix the standard up to which all makes of cement must come, and leaves no room for dispute, the above specifications being also recognized as standard by engineers throughout the country.

PRESIDENT ACKERMAN:—That is a very good suggestion and I will call on Mr. Schreiber to close the discussion.

MR. SCHREIBER:—I would like to explain that the waiting room shown in the appendices of Mr. Knight's paper as located at Morsemere, N. J., is not a design advocated by the Public Service Railway Co. The waiting room with closed sides was constructed by an Improvement Association and so far is the only one that I know of on the property. It was shown, I understand, only on account of the fact that a design very similar to it is used in some of the cities abroad. There is nothing more I have to add in closing, except to express my appreciation in behalf of the Committee to the gentlemen who have so kindly assisted in the discussions and to the members of the Association who co-operated with the Committee in furnishing data to make up the report.

MR. HANNA:—I move you, Mr. President, that the Report of the Committee on Buildings and Structures be approved and adopted and that a vote of thanks be tendered the Committee for its excellent report.

(Motion duly seconded, stated and carried unanimously.)

PRESIDENT ACKERMAN:—The next report we have before

us is that of the Committee on Standards, which I will ask Mr. Adams to present.

MR. ADAMS:—The report of the Committee on Standards covers the report of the meeting which was held in New York on November 6 and 7, 1911, at which meeting the Committee took action on the subjects which were approved at the Convention at Atlantic City a year ago this October, in accordance with the Rules of Procedure, that if matters, which are subjects for Standards or Recommended Practice, are approved by the Convention, they can then be forwarded to the Committee on Standards for action immediately after the Convention.

The next meeting was held in New York this year, on August 13 and 14, at which time suggestions, that had come from the standing committees to the Committee on Standards were taken under consideration. The matters which were considered at the November meeting in 1911, have all been submitted to the member companies, and I hardly think it necessary to go into details in reference to the same. The subjects, which are now before us, are those which were handled by the Committee on Standards at its meeting August 13 and 14, 1912, and as these subjects are in order the best method of procedure will be to take them up one at a time and take such action upon them as the Convention sees fit.

In order that a "Standard" or "Recommended Practice" may be adopted it is required that it receive the approval of the Convention and also of the Committee on Standards, or the approval of the Committee on Standards and then the approval of the Convention, it being necessary to have the approval of both, and as we take up the various items, you will notice what action has been taken in connection with the meeting of the Committee on Standards.

Certain of the items considered by the Committee at its meeting were referred back to the standing committees with the suggestion that if certain revisions could be made in them, and after receiving the approval of the Executive Committee, they could be submitted to the Convention at this meeting, and approved, that they could then be resubmitted to the Committee on Standards at the next meeting, which will be held within a short time after this Convention.

REPORT OF THE COMMITTEE ON STANDARDS

To the American Electric Railway Engineering Association:

GENTLEMEN:— Your Committee on Standards held its first meeting of the year at the headquarters of the Association in New York on November 6 and 7, 1911. There were present the following members: Paul Winsor, *Chairman,* H. H. Adams, *Vice-Chairman,* A. F. Hovey, M. V. Ayres, J. H. Hanna, M. H. Bronsdon, E. R. Hill, E. B. Katté, Martin Schreiber and J. M. Larned; also, Norman Litchfield, Secretary the Engineering Association. The following representatives of outside interests were present during the discussion of certain of the specifications: Henry Gulick, of Gulick-Henderson & Company; W. P. Barba, of The Midvale Steel Company; C. F. W. Rys, of the Carnegie Steel Company; F. S. Slocum, of Jones & Laughlin Steel Company; J. C. Wickersham, of the Pennsylvania Inspection Bureau; and A. A. Stevenson, of the Standard Steel Works Company.

The meeting was held in conformity with the rule No. 11 of Procedure for the Adoption of Standards, which requires that subsequent to Conventions the Committee on Standards shall hold a meeting at which will be considered changes made at Convention in the recommendations presented there, in order that such revised recommended Standards or Recommended Practice shall have the approval both of the Convention and of the Committee on Standards before being submitted to letter ballot of member companies.

The following is a brief synopsis of the matters discussed and action taken:

That the specifications for high tension, three conductor, paper insulated, lead covered cables, recommended by the Committee on Power Distribution and adopted by the 1911 Convention be approved as "**Standard.**" These specifications are given in full on pages 87–92, 1911 Proceedings.

That the specifications for single conductor, paper insulated, lead covered cable for 1200 volts, recommended by the Committee on Power Distribution and adopted by the 1911 Convention be approved as "**Standard.**" These specifications are given in full on pages 92–99, 1911 Proceedings.

That the sections for grooved trolley wire, 00 and 000, recommended by the Committee on Power Distribution and adopted by the 1911 Convention be approved as "**Standard.**" These specifications are given in full on page 99, 1911 Proceedings.

That the specifications for overhead crossings of electric light and power transmission lines, recommended by the Committee on Power Distribution and adopted by the 1911 Convention be approved as

"Standard." These specifications are given in full on pages 112-136, 1911 Proceedings.

Subsequently, as a result of conferences between representatives of member companies, the Engineering Association and the American Electric Railway Association, a communication from the Engineering Association was sent to the Executive Committee of the American Association suggesting the advisability, in view of newly developed conditions, of withholding these specifications from the proposed letter ballot in order that the Engineering Association might give the matter further attention. This recommendation was accepted by the American Association and the specifications were not therefore included in the letter ballot submitted to member companies on April 25, 1912.

That the specifications for 0 and 00 hard-drawn copper trolley wire, recommended by the Committee on Power Distribution, and adopted by the 1911 Convention be approved as **"Standard."** These specifications are given in full on pages 111 and 112, 1911 Proceedings.

That the specifications for heat-treated carbon steel axles, shafts and similar parts, recommended by the Committee on Equipment, and adopted by the 1911 Convention be approved as **"Standard."** These specifications are given in full on pages 172-174, 1911 Proceedings.

That the location and clearances for third-rail working conductors, recommended by the Committee on Heavy Electric Traction and adopted by the 1911 Convention be approved as **"Standard."** These specifications are given in full on pages 167–169, 1911 Proceedings.

That the definition of third-rail gauge and bond, recommended by the Committee on Heavy Electric Traction and adopted by the 1911 Convention be approved as **"Standard."** These definitions are given on pages 169, 1911 Proceedings.

Location of automatic train stops. (See page 170, 1911 Proceedings.) The Committee on Heavy Electric Traction recommended to the 1911 Convention the adoption of the location as Recommended Practice and the Convention approved. It was pointed out to the Committee on Standards, however, that in view of the importance of this question to steam railways, members of this Association, and to the members, generally, of the American Railway Association, that it would be advisable to recommend to the Executive Committee that the question be given further consideration and that it, therefore, be referred back to the Committee on Heavy Electric Traction with instructions to confer with the proper committee of the American Railway Engineering Association, which action was, on motion, duly approved.

Instructions to employees in the matter of fire protection, (see pages 424, 1911 Proceedings) and rules and regulations for the proper government of Employees of the Way Department, (see page 526, 1911 Proceedings) had been presented to the 1911 Con-

vention by the Committee on Buildings and Structures and the Committee on Way Matters, respectively, with recommendations that they be adopted as Recommended Practice and the Convention had approved the same. The Committee on Standards, however, in its consideration of these recommendations, after full discussion, agreed that neither was a matter which admitted of adoption as Recommended Practice, for the reason that each would to some degree have to be revised to meet local conditions. The Committee on Standards, therefore, while endorsing the developments referred to did not approve them for submission to letter ballot of member companies. The Committee further approved the recommendation of the Committee on Way Matters to the effect that the Secretary call the suggested rules to the attention of each member company along with request for suggestions as to changes and that the Committee on Way Matters in each subsequent year examine into suggested changes and additions and that these be brought to the attention of the Committee on Standards; also, that the Committee on Way Matters for 1911–1912 consider the revision of this book and investigate methods and systems of operation with illustrations of standard installations, with a view to incorporating in this code such additional instructions and rules as might seem desirable.

The Committee on Standards held a second meeting at the Association headquarters in New York on August 13 and 14, 1912. There were present at that meeting the following members of the Committee, Messrs. J. H. Hanna, J. M. Larned, L. P. Crecelius, F. R. Phillips, G. W. Palmer, Jr., Martin Schreiber, E. B. Katté, Geo. H. Pegram, and H. H. Adams, Vice-Chairman; also Norman Litchfield, Secretary, and Mr. F. Kingsley, representing the *Electric Railway Journal.*

In addition there were present the following representatives of manufacturing companies: O. C. Skinner and A. A. Stevenson, of the Standard Steel Works; H. P. Tiemann and C. F. W. Rys, of the Carnegie Steel Company; G. Aertsen and W. P. Barba, of The Midvale Steel Company; Frank Slocum, of Jones & Laughlin Company; Henry Gulick, of Gulick-Henderson Company; C. A. Alden, of the Pennsylvania Steel Company: and L. R. Ashhurst, Jr., of Wm. Wharton, Jr. & Company, Inc.

The subjects submitted by the standing committees for the consideration of the Committee on Standards and the action taken upon the same by the last-named Committee are as follows:

RECOMMENDATIONS OF THE COMMITTEE ON EQUIPMENT

The Committee on Equipment submitted for the consideration of the Committee on Standards the following:

Specifications for Annealed Carbon Steel axles, as Recommended Practice.

Specifications for Cold Rolled Steel Axles, as Recommended Practice.

Specifications for Forged and Solid Steel Wheels for Electric Railway Service, as Recommended Practice.

Specifications for Couplers for Interurban Cars where the Interchange of Equipment is Involved, as Recommended Practice.

Specifications for End Connections on Interurban Cars where the Interchange of Equipment is Involved, as Recommended Practice.

The action of your Committee on Standards relative to these recommendations was as follows:

That the "Specifications for Annealed Carbon Steel Axles" shown on page 775 of the 1912 Report of the Committee on Equipment be referred back to the Committee on Equipment, with the suggestion that it give consideration to a revision of same and, if consistent and after having received the approval of the Executive Committee, present the specifications at the coming meeting of the Association in Convention.

The reasons prompting the return of these Specifications to the Committee on Equipment are:

First — That the Committee on Equipment may give further consideration to the limits of the chemical composition;

Second — That consideration may be given to a revision of Paragraph No. 4.

Third — That a revision of the wording may be made in order that it may be in accord with the suggestions developed in the discussion of these specifications during the meeting of the Committee on Standards.

Fourth — That Paragraph No. 11 may be made explicit as to temperature and method of cooling.

That the "Specifications for Cold Rolled Steel Axles" be referred back to the Committee on Equipment, with the request that it consider the advisability of suggested changes and if consistent and after having received the approval of the Executive Committee, present the specifications at the coming meeting of the Association in Convention.

The reasons prompting the return of these Specifications to the Committee on Equipment are:

First — That the Committee on Equipment may give further consideration to the limits of the chemical composition.

Second — That consideration may be given to a re-wording of Paragraph No. 4.

The recommendation covering "Specifications for Forged and Solid Steel Wheels for Electric Railway Service" was thoroughly discussed by the Committee with the result that a divided vote was obtained. The Committee then submitted this along with other questions to the absent members of the Committee. The Rules of Procedure in the Matter of the Adoption of Standards require that a two-thirds affirmative vote is necessary to enable the Committee to recommend the adoption of Standards or Recommended Practices and the final vote upon this question not having met this requirement, the Committee is unable to meet the recommendation of the Committee on Equipment that these specifications be adopted as Recommended Practice.

That the recommendations submitted by the Committee on Equipment for "Couplers for Interurban Cars where the Interchange of Equipment is Involved" be approved as **"Recommended Practice."**

These specifications together with a discussion relative to the same, prepared by the Committee on Equipment, are given on page 677, in the Report of the Committee on Equipment.

That the recommendations of the Committee on Equipment as to the "Location of End Connections on Interurban Cars where the Interchange of Equipment is Involved" be adopted as **"Recommended Practice."** These specifications are submitted together with a discussion relative to the same prepared by the Committee on Equipment for which see page 677, of the Report of the Committee on Equipment.

RECOMMENDATIONS OF THE COMMITTEE ON POWER DISTRIBUTION.

The Committee on Power Distribution submitted the following recommendations for the consideration of the Committee on Standards:

Specifications for the Joint Use of Poles.

Specifications for Overhead Crossings of Foreign Wires with Electric Railway Wires.

Concrete, Lattice and Tubular Poles, including Settings for Iron Poles.

High Grade Rubber Insulating Compound.

Standard Stranding Table.

Revision of the Copper Wire Table now **"Standard."**

Trolley Guards.

Revision of Specifications for High Tension, Three Conductor, Paper Insulated, Lead Covered Cable.

Revision of Specifications for Single Conductor, Paper Insulated, lead Covered Cable for 1200 Volts.

Revision of Specifications for Overhead Crossings of Electric Light and Power Transmission Lines.

The action of the Committee on Standards relative to the recommendations was as follows:

That the recommendation of the Committee on Power Distribution relative to "Specifications for the Joint Use of Poles" be approved. The recommendation is as follows:

The American Electric Railway Association has appointed a committee, of which Mr. W. J. Harvie is *Chairman,* to consider the matter of a proposed standard form of agreement for the joint use of poles, the specification for line construction being only a part thereof. The Committee on Power Distribution is represented on this committee by Mr. A. S. Richey. It appears, therefore, that the Committee on Power Distribution having been relieved from consideration of this matter, further investigation by it is not warranted, except at the request of the first named committee.

That the recommendation of the Committee on Power Distribution relative to "Specifications for Overhead Crossings of Trolley Contact Wires over Railway Tracks" be approved. The recommendation is as follows:

The Committee on Power Distribution has adopted a specification covering specifications for overhead crossings of trolley contact wires over railway tracks. Inasmuch, however, as it has not been considered jointly with the other interests involved, it is recommended that the Committee on Power Distribution be given more time to investigate.

That the recommendation of the Committee on Power Distribution relative to "Specifications for Overhead Crossings of Foreign Wires with Electric Railway Wires" be approved. The recommendation is as follows:

The Committee on Power Distribution has adopted specifications covering this subject. Inasmuch, however, as it has not been considered jointly with the other interests involved, it is recommended that the Committee be given more time to investigate.

That the recommendation of the Committee on Power Distribution relative to Concrete, Lattice and Tubular Poles be approved. The recommendation is as follows:

The Committee not being ready at this time to make its final report, it is recommended that more time be given for investigation.

That the recommendation of the Committee on Power Distribution relative to high grade rubber insulating compound be approved. The recommendation is as follows:

This subject is being considered jointly by this Committee and the Committee on Equipment. The final report not being ready at this time it is recommended that more time be given for investigation.

That the recommendation of the Committee on Power Distribution relative to Standard Stranding Table be approved as "**Standard.**" The recommendation of the Committee is as follows:

It is recommended that the stranding and properties thereof expressed in Tables XII and XIII, Pages 50 and 51, U. S. Bureau of Standards, Circular No. 31, April 1, 1912, be adopted by the Association as Standard. These Tables are in accord with the standards adopted by the Standards Committee of the A. I. E. E. both in respect to the number of wires, standard strands and in flexible strands and in respect to the correction and increase of resistance and mass due to the twist of the wires.

(These tables are shown on pages 144 to 146 in the report of the Committee on Power Distribution.)

The Committee on Standards while approving the first part of the recommendation submitted by the Committee on Power Distribution, pertaining to the revision of the Copper Wire Tables, considered that this subject should be presented complete with the working tables and therefore, the subject was referred back to the Committee with the suggestion that if the working table is complete and ready for presentation to the coming Convention, that the Committee on Power Distribution submit the same after receiving the approval of the Executive Committee, in order that the complete recommendation may be considered by the Association in Convention. The recommendation of the Committee on Power Distribution relative to the revision of the copper wire table is as follows:

The Standards Committee of the American Institute of Electrical Engineers has adopted as Standard the Copper Wire Table as published in Circular No. 31 of the U. S. Bureau of Standards, Tables VI and VII, Pages 38, 39, 40, 41, 42, 43, 44, 45. It is therefore recommended that the above named tables be adopted by the Association as "**Standard.**" It is also recommended that abbreviated tables based upon the above-named tables for use as working tables be adopted by the Association as "**Standard**" Working Tables.

(These tables are shown on pages 126 to 141 in the report of the Committee on Power Distribution.)

That the recommendation of the Committee on Power Distribution relative to Trolley Guards be disapproved and referred back to the Committee. The recommendation so disposed of is given on page 103 of the report of that Committee.

The subject of trolley guards was referred back to the Power Distribution Committee for further consideration, with the suggestion that the matter be considered in connection with the subject of overhead crossings of trolley contact wires for railway tracks, it also being the opinion of the Committee on Standards that this subject is one which should not be adopted either as Standard or Recommended Practice, because of the varying conditions which apply.

That the recommendation of the Committee on Power Distribution relative to the revision of the "Specifications for High Tension, Three Conductor, Paper Insulated, Lead Covered Cable" be approved. The recommendation is as follows:

Page 87, Title, Substitute the word "voltage" for the word "tension" and the word "cable" for the final word "cables" so that the title shall read "Specifications for High Voltage, Three Conductor, Paper Insulated, Lead Covered Cable."

Conductors

Strike out the words "Intermediate sizes take the stranding of the next larger listed size."

The last paragraph to be amended to read as follows:

"Each of the individual wires shall have a resistivity of not more than 888.55 ohms (mile, pound), at 20° C."

After careful consideration the Committee recommends no further revision of these specifications.

The revised specifications are printed herewith complete, including revisions, which are shown in italics.

Specifications for High *Voltage*, Three Conductor, Paper Insulated, Lead Covered *Cable*

Definition of Terms.

The word "Company," where occurring in these specifications, shall mean the purchaser of the cable hereinafter referred to, or its duly authorized representative.

The word "Contractor," where occurring in these specifications, shall mean the party accepting the order to furnish the cable hereinafter referred to, or its duly authorized representative.

General Description.

The cable is to be composed of three copper conductors of the size specified in the order, each separately covered with paper tape to the required thickness, and then twisted together with a suitable lay. The interstices are to be rounded out with jute and the whole wrapped with a paper belt to the required thickness. The paper, soaked in a

suitable insulating compound, is to be covered with a lead sheath of the required thickness. The completed cable, and the materials of which it is made, shall conform to the requirements of the following specifications and tests:

Conductors.

Each conductor shall consist of annealed copper wires, free from splints, flaws or other defects, concentrically stranded together in reverse spiral layers, and having an aggregate cross sectional area when measured at right angles to the axes of the individual wires at least equal to the area of the specified size, and in accordance with the following table:

Size of conductor.	No. of wires.
0.162 in. — 0.204 in. diameter	1
0.229 in. — 0.258 in. diameter	7
0.289 in. — 0.460 in. diameter	19

Each of the individual wires shall have a *resistivity of not more than 888.55 ohms (mile, pound), at 20 deg. C.*

Insulation.

The highest grade of pure manila rope paper tape shall be applied helically and evenly to each of the conductors until a thickness of paper not less than ..... inch is obtained.

The conductors shall then be twisted together, with a suitable lay of at least one complete twist in each 24 in. of length of cable. The interstices of the core so formed shall be filled in with jute laterals, of the proper dimensions to form a true cylinder.

The paper tape shall then be applied helically and evenly over the core until a thickness not less than ..... inch is obtained.

All moisture shall be expelled from the paper and jute by baking in suitable ovens; they shall then be thoroughly saturated with the insulating compound, of the required kind and quality.

The paper tape must be applied to the conductors and the core in such a manner, and the insulating compound must be of such a nature, that the cable will be capable of being bent to a radius of 18 in. when wound on reels and taken therefrom and put into place, at any temperature between 0 deg. and 100 deg. Fahr., without damage to the insulation or sheath.

Insulating Compound.

The insulating compound shall contain no substance which will subject the paper, jute or conductors to deterioration, and it shall be of such composition as to maintain the insulation in a soft, plastic state at all seasons of the year.

Sheath.

A sheath of a uniform thickness, not less than that indicated in the following table, shall be tightly formed about the core:

Diameter of core in mils.	Thickness of sheath.
Under 1999	1/8 in.
2000—2699	9/64 in.
2700 and over	5/32 in.

A sheath having an internal diameter less than 2 in. shall consist of commercially pure lead. A sheath having an internal diameter of 2 in. or more shall consist of an alloy containing not less than 98 per cent. of commercially pure lead, and not less than 1 per cent. of commercially pure tin.

Working Conditions.

The working potential of the cable will be ..... effective volts between conductors and ..... volts between each conductor and the ground.

Tests.

Each length of cable shall be tested for the following requirements, after all the working operations on the cable are completed. The conditions and conduct of tests shall conform to the recommendations of the American Institute of Electrical Engineers, unless otherwise herein stated.

Dielectric Strength.

An alternating current voltage shall be applied between each conductor and all the others connected to the lead sheath, for a period of at least five minutes. The voltage to be applied shall be that corresponding to the combined thickness of the conductor and belt insulation in accordance with the following table:

Voltage.	Thickness of insulation.
5,000	9/64 in.
6,250	5/32 in.
7,500	3/16 in.
10,000	7/32 in.
12,500	1/4 in.
15,000	9/32 in.
20,000	5/16 in.
25,000	11/32 in.
30,000	3/8 in.
35,000	13/32 in.
40,000	7/16 in.
45,000	15/32 in.
50,000	1/2 in.
60,000	9/16 in.

The cable must not show any weakening of its insulation or any other injury under this test, which is to be made before the test for insulation resistance.

Insulation Resistance.

Immediately after the dielectric test, a test shall be made for insulation resistance, each conductor being measured against all the others connected to the lead sheath. The measurement shall be taken after one minute electrification, using an e. m. f. of not less than 100 volts, and shall be not less than 50 megohms per mile at 60 deg. Fahr.

Inspection and Record of Tests.

All electrical tests for the foregoing requirements shall be made at the factory with apparatus furnished by the Contractor, and in the presence of the Company (unless expressly agreed to the contrary), which shall be given every facility to satisfy itself as to the reliability of the tests and their results before the cable is delivered. A copy of the record of all tests is to be sent by the Contractor to the Company.

Sample.

In addition to the length of cable ordered, if required by the Company, a sample at least 18 in. in length, selected at random by the Company from each 2,000 ft. of cable (and at least one sample if the cable ordered is less than 2,000 ft. in length), shall be furnished the Company. The samples shall be cut off after all work on the cable, as well as the foregoing tests, have been completed. The samples may, if the Company desires, be tested for ultimate dielectric strength between each conductor and the sheath. The break-down voltage of any test shall be not less than that corresponding to the combined thickness of the conductor and belt insulation in accordance with the following table:

Voltage.	Thickness of insulation.
12,000	9/64 in.
14,000	5/32 in.
18,000	3/16 in.
21,000	7/32 in.
25,000	1/4 in.
31,000	9/32 in.
37,000	5/16 in.
44,000	11/32 in.
50,000	3/8 in.
56,000	13/32 in.
63,000	7/16 in.
69,000	15/32 in.
75,000	1/2 in.
81,000	17/32 in.
87,000	9/16 in.

Packing.

Both ends of each length of cable must be hermetically sealed before shipment. The cable shall be so packed for shipment that it will be protected from injury; each reel shall be plainly marked, giving length of cable, working voltage, Company's order number, size of conductors and date of manufacture. Each reel must have a numbered metal tag permanently attached, in a proper counterbore.

Failure to Meet Requirements.

Any length of cable which fails to pass the above requirements may be rejected.

Guarantee.

The Contractor shall guarantee that for five years from the time the cable is placed, spliced and connected, its insulation resistance shall not decrease below the limits above specified. The Contractor shall also guarantee to restore, or cause to be restored, all cables that may be damaged by the failure, before the expiration of its guaranteed period, of the cable furnished under these specifications.

In case, however, the decrease in insulation resistance or failure of the cable results from lightning, mechanical injury, or other causes beyond the control of the Contractor, he shall be relieved from the guarantee obligations.

Installation by Contractor

If the cable is to be installed by the Contractor, the following should be added to the foregoing specifications:

Installation.

The Contractor shall install the cable in the ducts of the Company. The Company will assign, clear and wire the ducts. The Contractor, however, must assure himself that the ducts are properly cleared before pulling in the cable.

Cable supports will be installed in the manholes by the Company. The Contractor shall arrange the cables in the manholes under the direction and to the satisfaction of the Company.

Splicing.

The Contractor shall furnish all necessary splicing material for the joints, which shall be made by men experienced in such work. The conductivity, insulation and dielectric strength of a completed splice shall be not less than that of an equal length of cable. The thickness of the joint sleeves shall be not less than that of the cable sheath. The ends of the cable sheaths inside the joint sleeves shall be properly belled. Splices shall be in manholes only, and there shall be but one splice per cable length in any manhole.

Protectors.

The Contractor shall furnish and place a protector, of a type approved by the Company, under the cable at each duct opening. The Contractor shall also furnish and place protectors between the cable and manhole supports where required, and as directed by the Company. No cable shall be spliced until after its duct protectors have been placed in position.

Test after Installation.

Unless waived by the Company, each completed length of the cable shall, after the installation of the same is finished, be subjected to the tests for dielectric strength and insulation resistance as hereinbefore specified, except that the Company will supply all apparatus for the tests, and the voltage used in the dielectric strength test shall be 80 per cent of the voltage specified for the factory test.

Cable Protection in Manholes.

The Contractor shall, unless expressly otherwise agreed, furnish and place a protective covering on the entire length of the cable in the manholes. The covering shall consist of .....
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Reels.

The Contractor shall be responsible for all reels and lagging.

That the recommendation of the Committee on Power Distribution relative to revision of "Specifications for Single Conductor, Paper Insulated, Lead Covered Cable for 1,200 Volts" be approved. The recommendations are as follows:

Revision of Specifications for Single Conductor, Paper Insulated, Lead Covered Cable for 1,200 Volts.

Page 93. The following stranding to be substituted for the last two lines of the table:

1,100,000 — 1,500,000	91
1,600,000 and larger	127

The last paragraph to be amended to read as follows:

"Each of the individual wires shall have a resistivity of not more than 888.55 ohms (mile pound), at 20° C."

After careful consideration the Committee recommends no further revision of these specifications.

The complete specifications are printed herewith, including the re visions, which are shown in italics.

SPECIFICATIONS FOR SINGLE CONDUCTOR, PAPER INSULATED, LEAD COVERED CABLE FOR 1,200 VOLTS.

Definition of Terms.

The word "Company," where occurring in these specifications, shall mean the purchaser of the cable hereinafter referred to, or its duly authorized representative.

The word "Contractor," where occurring in these specifications, shall mean the party accepting the order to furnish the cable hereinafter referred to, or its duly authorized representative.

General Description.

The cable is to be composed of a single conductor of the size specified in the order, covered with paper tape to the required thickness. The paper, soaked in a suitable insulating compound, is to be covered with a lead sheath of the required thickness. The completed cable and the materials of which it is made shall conform to the requirements of the following specifications and tests:

Conductor.

The conductor shall consist of annealed copper wires, free from splints, flaws or other defects, concentrically stranded together in reverse spiral layers, and having an aggregate cross sectional area when measured at right angles to the axes of the individual wires at least equal to the area of the specified size, and in accordance with the following table:

Size of conductor.	No. of wires.
0.162 in. — 0.204 in. diameter	1
0.229 in. — 0.258 in. diameter	7
0.289 in. — 0.460 in. diameter	19
300,000 — 500,000 c. m	37
600,000 — 1,000,000 c. m	61
1,100,000 — 1,500,000 c. m	*91*
1,600,000 and larger c. m	*127*

Intermediate sizes take the stranding of the next larger listed size.

Each of the individual wires shall have a *resistivity of not more than 888.55 ohms (mile, pound), at 20 deg. C.*

Insulation.

The highest grade of pure manila rope paper tape shall be applied helically and evenly to the conductor until a thickness of paper not less than .... inch is obtained.

All moisture shall be expelled from the paper by baking in suitable ovens; it shall then be thoroughly saturated with the insulating compound, of the required kind and quality.

The paper tape must be applied to the conductor in such a manner, and the insulating compound must be of such a nature, that the cable will be capable of being bent to a radius of 12 in. when wound on reels and taken therefrom and put into place, at any temperature between 0 deg. and 100 deg. Fahr., without damage to the insulation or sheath.

Insulating Compound.

The insulating compound shall contain no substance which will subject the paper or conductor to deterioration, and it shall be of such composition as to maintain the insulation in a soft, plastic state at all seasons of the year.

Sheath.

A sheath of uniform thickness, not less than ⅛ in. for cable under 1½ in. core diameter, and not less than 9/64 in. for cable with core diameter 1½ in. and larger, shall be tightly formed about the core.

A sheath having an internal diameter less than 1½ in. shall consist of commercially pure lead. A sheath having an internal diameter of 1½ in. or more shall consist of an alloy containing not less than 98 per cent of commercially pure lead, and not less than 1 per cent of commercially pure tin.

Tests.

Each length of cable shall be tested for the following requirements after all the working operations on the cable are completed. The conditions and conduct of tests shall conform to the recommendation of the American Institute of Electrical Engineers, unless otherwise herein stated.

Dielectric Strength.

An alternating current of 5,000 volts shall be applied between the conductor and the lead sheath for a period of 5 minutes. The cable must not show any weakening of its insulation or any other injury under this test, which is to be made before the test for insulation resistance.

Insulation Resistance.

Immediately after the dielectric test, a test shall be made for insulation resistance. The measurement shall be taken after one minute electrification, using an e. m. f. of not less than 100 volts, and shall be not less than 50 megohms per mile at 60 deg. Fahr.

Inspection and Record of Tests.

All electrical tests for the foregoing requirements shall be made at the factory with apparatus furnished by the Contractor, and in the

presence of the Company (unless expressly agreed to the contrary), which shall be given every facility to satisfy itself as to the reliability of the tests and their results before the cable is delivered. A copy of the record of all tests is to be sent by the Contractor to the Company.

Sample.

In addition to the length of cable ordered, if required by the Company a sample at least 18 in. in length, selected at random by the Company from each 2,000 ft. of cable (and at least one sample if the cable ordered is less than 2,000 ft. in length), shall be furnished the Company. The samples shall be cut off after all work on the cable, as well as the foregoing tests, have been completed. The samples may, if the Company desires, be tested for ultimate dielectric strength between the conductor and the sheath. The break-down voltage of any test shall be not less than 14,000 volts.

Packing.

Both ends of each length of cable must be hermetically sealed before shipment. The cable shall be so packed for shipment that it will be protected from injury; each reel shall be plainly marked, giving length of cable, working voltage, Company's order number, size of conductors, and date of manufacture. Each reel must have a numbered metal tag permanently attached, in a proper counterbore.

Failure to Meet Requirements.

Any length of cable which fails to pass the above requirements may be rejected.

Guarantee.

The Contractor shall guarantee that for five years from the time the cable is placed, spliced and connected, its insulation resistance shall not decrease below the limits above specified. The Contractor shall also guarantee to restore, or cause to be restored, all cables that may be damaged by the failure, before the expiration of its guaranteed period, of the cable furnished under these specifications.

In case, however, the decrease in insulation resistance or failure of the cable results from lightning, mechanical injury, or other causes beyond the control of the Contractor, he shall be relieved from the guarantee obligations.

Installation by Contractor

If the cable is to be installed by the Contractor, the following should be added to the foregoing specifications:

Installation.

The Contractor shall install the cable in the ducts of the Company. The Company will assign, clear and wire the ducts. The Contractor,

however, must assure himself that the ducts are properly cleared before pulling in the cable.

Cable supports will be installed in the manholes by the Company. The Contractor shall arrange the cables in the manholes under the direction and to the satisfaction of the Company.

Splicing.

The Contractor shall furnish all necessary splicing material for the joints, which shall be made by men experienced in such work. The conductivity, insulation and dielectric strength of the completed splice shall be not less than that of an equal length of cable. The thickness of the joint sleeves shall be not less than that of the cable sheath. The ends of the cable sheaths inside the joint sleeves shall be properly belled. Splices shall be in manholes only, and there shall be but one splice per cable length in any manhole.

Protectors.

The Contractor shall furnish and place a protector, of a type approved by the Company, under the cable at each duct opening. The Contractor shall also furnish and place protectors between the cable and manhole supports where required and as directed by the Company. No cable shall be spliced until after its duct protectors have been placed in position.

Test After Installation.

Unless waived by the Company, each completed length of the cable shall, after the installation of the same is finished, be subjected to the tests for dielectric strength and insulation resistance as hereinbefore specified, except that the Company will supply all apparatus for the tests, and the voltage used in the dielectric strength test shall be 4,000 volts.

Cable Protection in Manholes.

The Contractor shall, unless expressly otherwise agreed, furnish and place a protective covering on the entire length of the cable in the manholes. The covering shall consist of .....
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Reels.

The Contractor shall be responsible for all reels and lagging.

That the recommendation of the Committee on Power Distribution, relative to the revision of "Specifications for Overhead Crossings of Electric Light and Power Transmission Lines," be approved. The recommendation is as follows:

The Committee feels that these specifications should not be adopted by the Engineering Association either as Standard or as Recommended Practice, except after favorable action by the steam railroad interests and, therefore, recommends that the Committee be given more time to investigate with a view to recommending adoption at such time.

That the recommendation of the Committee on Power Distribution, relative to the standard section of Grooved Trolley Wires be approved and recommends that in the re-printing of this **"Standard,"** amplified drawings be substituted for the original ones. The recommendation of the Committee on Power Distribution is as follows and is shown in Fig. 1, page 109, of the report of that Committee.

That the recommendation of the Committee on Power Distribution relative to "Electric Wire and Cable Terminology," be approved as **"Standard."** The recommendation of the Committee together with a discussion relative to the same, is shown on pages 111 and 173 of the Report of that Committee.

RECOMMENDATIONS OF THE COMMITTEE ON WAY MATTERS

The Committee on Way Matters submitted the following recommendations for the consideration of the Committee on Standards:

1. Revision of the Association's "Specifications for Open Hearth Girder and High T-Rails," as Recommended Practice.
2. Designs of Rail Sections for Grooved Girder Rail Sections, as Standard.
3. Designs of Rail Sections for Grooved Guard Girder Rails, as Standard.
4. Designs of Joint Plates for Grooved Rail Sections, as Recommended Practice.

That the recommendations of the Committee on Way Matters, relative to "Specifications for Open Hearth Girder and High T-Rails," be approved as **"Recommended Practice."** The specifications are printed in full showing the revisions in the same on pages 601 to 613 in the Report of the Committee on Way Matters.

That the recommendations of the Committee on Way Matters, relative to the designs of Rail Sections for Grooved Girder and Grooved Guard Rail Sections, be disapproved and referred back to the Committee on Way Matters for further action, for the reason that objection has been made to the shape of the guard section and in the opinion of the Committee on Standards changes in the guard section might affect the section of the Grooved Rail.

That the recommendation of the Committee on Way Matters, relative to the Design of Joint Plates be disapproved and referred back to the Committee on Way Matters for further consideration in connection with the further revision of the Girder Grooved and Guard Rails.

RECOMMENDATIONS OF THE COMMITTEE ON HEAVY ELECTRIC TRACTION

That the recommendation of the Committee on Heavy Electric Traction, relative to Clearance Lines for Third Rail and Permanent Way Structures and Rolling Equipment," be approved as **"Standard."** The recommendation of the Committee is shown in Fig. 2, page 652b, of the Report of the Committee on Heavy Electric Traction.

Respectfully submitted,
PAUL WINSOR, *Chairman,*
H. H. ADAMS, *Vice-Chairman,*
J. H. HANNA,
J. M. LARNED,
L. P. CRECELIUS,
MARTIN SCHREIBER,
E. B. KATTÉ,
F. R. PHILLIPS,
G. H. KELSAY,
G. W. PALMER, JR.,
E. R. HILL,
GEO. H. PEGRAM,
CHAS. H. CLARK.
Committee on Standards.

Discussion of Report of Committee on Standards

(Secretary Litchfield read the recommendations submitted to the Committee on Standards by the Committee on Equipment, see page 375.)

MR. ADAMS:— For the information of those present, I will say that the Committee on Equipment is prepared to submit their revision of the Specifications for Annealed Carbon Steel Axles on Friday morning.

(Secretary Litchfield then read the last paragraph on page 375.)

MR. ADAMS:— The Committee on Equipment is also prepared to submit a revision of these Specifications for Cold Rolled Steel Axles on Friday morning.

(The secretary then read the reasons that prompted the return of the Specifications for Cold Rolled Steel Axles by the Committee on Standards, see page 376.)

(The secretary then read the paragraphs on page 376 covering the Specifications for Forged and Solid Steel Wheels for Electric Railway Service and Couplers for Interurban Cars where the Interchange of Equipment is Involved.)

SECRETARY LITCHFIELD:— That, therefore, is the first definite thing before you this morning. Is that correct, Mr. Chairman?

MR. ADAMS:— That is correct.

PRESIDENT ACKERMAN:— Gentlemen, you have heard the recommendation of the Committee. What disposition shall be made of it?

MR. PALMER:— I move that the Specifications for Couplers for Interurban Cars where the Interchange of Equipment is Involved, as submitted by the Committee on Equipment and approved by the Committee on Standards, be adopted as **Recommended practice.**

(Motion seconded.)

MR. SIBBALD:— The Interstate Commerce Commission requires, with reference to the sixth item of the specifications for couplers, that the uncoupling device be operated from the left hand side of the car as you face the car, on all cars that are used in freight or mixed service. On this account I suggest that the requirement of the Interstate Commerce Commission be incorporated in these specifications.

MR. RICHEY:— I have no criticism to make on the specifications, but I think that where the M. C. B. requirements are mentioned, as in different places in the report, that when the report is finally printed in the proceedings a supplement at least of these M. C. B. requirements should be added so that when using these specifications it is not necessary to look up the M. C. B. specifications in order to obtain our complete specifications for couplers.*

(President Ackerman then put the motion made by Mr. Palmer, which was duly carried.)

NOTE:— The M. C. B. Specifications were not available at the time of going to press, but will be provided in connection with the Standards in loose leaf form. [Ed]

MR. ADAMS:— The next item to be considered is that of — Specifications for End Connections on Interurban Cars Engaged in the Interchange of Cars. The Secretary will kindly read the discussion of the Equipment Committee on this subject and the recommendation of the Committee.

(Secretary Litchfield read the Specifications for End Connections on Interurban Cars Engaged in the Interchange of Cars and the recommendations of the Committee on Standards. See page 376.)

PRESIDENT ACKERMAN:—You have the subject before you, which the Committee recommends be adopted as "Recommended Practice." What is your pleasure?

MR. SAWYER:— I move that the recommendation of the Committee on Equipment and approved by the Committee on Standards regarding End Connections on Interurban Cars Engaged in the Interchange of Cars be adopted as **Recommended Practice.**

(Motion duly seconded, stated and carried.)

MR. ADAMS:— The next subjects which we have for consideration are the recommendations of the Committee on Power Distribution, which appear on pages 376 and 377.

MR. RICHEY:— In that connection I would ask if it is necessary to go over all these things again, as on Monday the Convention took action on every one of them, I believe.

MR. ADAMS:— We will make progress by going through them, and only taking action upon those requiring the approval of the Convention.

MR. RICHEY:—As long as action was taken by the Convention on Monday on all of these items, would it not be possible to complete the formality of the session here this morning by approving the report of the Committee on Standards as a whole, as it relates to the Power Distribution Committee. If that is in order I would move the acceptance of the report of the Committee on Standards in relation to the matters suggested by the Committee on Power Distribution, as we have been over the whole thing once and spent considerable of time on it.

MR. ADAMS:— That would mean, if there is no objection, that the first item for consideration is the recommendation of the Committee on Power Distribution relative to the Standard Stranding Table. The recommendation of the Committee appears on page 378.

MR. SAWYER:— I move that the Standard Stranding Table as recommended by the Committee on Power Distribution and approved by the Committee on Standards be adopted as **Standard.**

MR. MCCOLLUM:— The National Bureau of Standards has done a good deal of work along the lines which led up to the preparation of this stranding table, and it seems well to make a few statements in regard to the history of the investigation that first led to the standardization of the stranded wire tables. You all perhaps know that up to 1907 the American Institute of Electrical Engineers had a copper wire standard, but at that time they adopted a new value for the temperature coefficient of copper, and on the adoption of the new value, 0.0042 per deg. C., the old table became inaccurate for all temperatures other than zero. That table was continued for some time with the understanding that it was inaccurate for temperatures other than zero degrees, and in the meantime the question of the recalculation of the table was discussed, but it was recognized that sufficient data was not at hand on which to base the recalculation of the table, consequently the Standards Committee of the Institute brought the matter to the attention of the Bureau of Standards and requested that they undertake an investigation which would yield more modern data on which to base the recalculation of the old table. That investigation was undertaken by the Bureau of Standards early in 1910 and when completed the results of the investigation were placed before the Standards Committee in September, 1910.

The investigations covered a determination of the conductivity of annealed copper wire and involved a large number of determinations on a great number of representative commercial samples. It also dealt with the determination of the

temperature coefficient of resistance of copper. It was found that the former standard of the conductivity of the Institute, 0.153022 ohms per metergram, was substantially correct and sufficiently accurate to justify its continuance. It was further found that the temperature coefficient had a very definite relation to the conductivity of the copper, and is, in fact, directly proportional to it. Copper having a conductivity of 100 per cent. has a certain temperature coefficient of resistance. If the conductivity increases 2 per cent. the temperature coefficient likewise increases 2 per cent., and this holds true, no matter what may be the cause of the change in the resistance of the copper, whether due to chemical composition, or physical change due to strain, or to whatever cause. It was established by that investigation that if the resistance of any specimen of copper be measured at two different temperatures its specific resistance could be calculated from the change in resistance which occurs.

The work done by the Bureau of Standards was reported to the Standards Committee of the Institute in September, 1910, and was approved by that Committee and adopted as its standard.

Before going further, however, it was decided to take the matter up with the International Electro Technical Commission with a view to agreeing on a value that might be accepted as an International standard. When the matter was taken up by the International Commission, the representatives of Germany proposed a value slightly different from the former standard of the United States, which was recommended to be continued by the Bureau, and that value was about one sixth of a per cent. larger than the value proposed by the Institute. In order to agree upon an International standard, therefore, the International Electro Technical Commission decided to adopt the German value for specific resistance which was sufficiently close for practical purposes and the value of the temperature coefficient as determined by the Bureau of Standards and accepted by the Standards Committee of the Institute, namely, 0.00393.

These values have been adopted by the Standards Committee of the American Institute of Electrical Engineers and by the Bureau of Standards and are the values given in this table which is now presented to this Association for adoption.

In proceeding in the matter, you are not voting, simply on the value that has been suggested for adoption as a National standard, but on a value that is practically certain to be adopted as an International standard.

(The motion made by Mr. Sawyer was duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— There will be no action taken on the subject of Trolley Guards as that was disposed of at the meeting on Monday.

The next matter to be considered will be — Revision of Specifications for High Voltage, Three Conductor, Paper Insulated, Lead Covered Cables, page 379.

MR. SAWYER:— I move that the recommendation of the Committee on Power Distribution, regarding changes in the Specifications for High Tension, Three Conductor, Paper Insulated, Lead Covered Cables and approved by the Committee on Standards, be adopted.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next matter to be considered will be that relating to the Revision of Specifications for Single Conductor, Paper Insulated, Lead Covered Cable for 1200 Volts, page 385.

MR. SAWYER:— I move that the recommendation of the Committee on Power Distribution regarding the changes in Specifications for Single Conductor, Paper Insulated, Lead Covered Cables and approved by the Committee on Standards be adopted.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject to be considered is Revision of Specifications for Overhead Crossings of Electric Light and Power Transmission Lines, page 389.

MR. SAWYER:— I move that the recommendation of the Committee on Standards regarding the Specifications for

Overhead Crossings of Electric Light and Power Transmission Lines be approved.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject to be considered is Electric Wire Cable Terminology, which appears on page 389.

MR. KELSAY:— I move that the Electric Wire and Cable Terminology as recommended by the Committee on Power Distribution and approved by the Committee on Standards be adopted as **Standard.**

(The motion made by Mr. Kelsay having been duly seconded was put to vote and carried.)

PRESIDENT ACKERMAN:— The next subjects for your consideration are the recommendations which have been submitted to the Committee on Standards by the Committee on Way Matters, page 389.

MR. ADAMS:—As to the recommendations of the Committee on Way Matters, there is really only one which is up for consideration at this time, and that is the first one, the Revised Specifications for Open-Hearth Girder and High T-Rails. The others were referred back to the Committee on Way Matters by the Committee on Standards, and I hardly think it necessary to read these specifications, as they have already been printed in the proceedings, are somewhat lengthy, and are simply a revision of the specifications that have been approved by the Association previous to this time. These specifications have also been approved by the American Society for Testing Materials working in conjunction with a subcommittee of our Committee on Way Matters. If there is no objection the specifications will not be read. Under these circumstances we can then take up the recommendation which is as follows:

"That the recommendation of the Committee on Way Matters relative to Specifications for Open-Hearth Girder and High T-Rails be approved as 'Recommended Practice.'" The specifications are printed in full showing the revisions that have been made.

MR. SCHREIBER:— I move that the Revised Specifications for Open-Hearth Girder and High T-Rails as recommended

by the Committee on Way Matters and approved by the Committee on Standards be adopted as **Recommended Practice.**

(Motion duly seconded, stated and carried.)

MR. ADAMS:— The next item for consideration is the recommendation of the Committee on Heavy Electric Traction, page 390.

The Committee on Heavy Electric Traction has been working in conjunction with a Committee of the American Railway Association in connection with this particular recommendation, and they are a unit on the same. The other Association has approved as Standard this recommendation.

SECRETARY LITCHFIELD:— I wish to call the attention of the members to two matters in connection with our "Standards"— one has just been approved, in connection with the open-hearth girder or high T-rail, and I believe the other is about to be approved in connection with the recommendation from the Committee on Heavy Electric Traction. The American Society for Testing Materials has adopted our specifications for high T-rails.

MR. LARNED:— They have made some modifications, but they practically are our specifications.

SECRETARY LITCHFIELD:—The second set of specifications to which I refer, that of the matter of clearances, as referred to in the recommendations of the Committee on Heavy Electric Traction is, of course, of increasing importance. Our Committee and representatives of large steam railroads, which have electrified divisions, have been working with the American Railway Engineering and the American Railway Associations. Whether they have definitely approved these details or not, I am not in a position to say, but I think they have. The report which is now presented to you, however, has received the sanction of all parties interested. I feel assured that in voting on these two recommendations you are voting on matters which will meet with the approval of all concerned and will make their weight felt.

PRESIDENT ACKERMAN:— The question before you is that the recommendation of the Committee on Heavy Elec-

tric Traction relative to Clearance Lines for Third-Rail and Permanent Way Structures and Rolling Equipment be approved as Standard.

MR. SAWYER:—I move that the Limiting Clearance Lines for Third-Rail and Permanent Way Structures and Rolling Equipment as recommended by the Committee on Heavy Electric Traction and approved by the Committee on Standards be adopted as **Standard.**

(Motion duly seconded, stated and carried.)

MR. ADAMS:—Before taking formal action on the report as a whole, I desire to make a remark or two on this question which Mr. Litchfield has just spoken about, that is, the question of the adoption of recommended Standards. The Committee on Standards is practically the clearing house for Association work; but I hope that the members, and particularly the Chairmen of standing committees will not think it incumbent upon them to pass up to the Committee on Standards a volume of work. The Committee on Standards is looking for quality rather than quantity, and we would rather pass through that Committee a few "Standards" which, as Mr. Litchfield said, will be of weight and standing than a large number which will go into the proceedings and perhaps be forgotten. I want to bring this up, so that it may go into the record, that the Committee on Standards in its work feels that at the present time there is too much being sent to it for consideration, that there is a large amount of this work which could remain in the reports of the standing committees, and after receiving the approval of the Association, have sufficient weight and standing, in other words, the approval of certain methods by the Convention is sufficient to bring them into the proceedings and to the notice of member companies so that they may have these methods for use if desired. It is not necesssary to pass everything through the Committee on Standards, but send only such matters to the Committee on Standards as should have the highest action of the Association for adoption as "Standard" or "Recommended Practice."

MR. PALMER:— Speaking of the volume of work referred to the Committee on Standards, the instructions issued to the chairmen of committees, by which they were to carry on their work, were to the effect that not later than July the chairman of each committee shall make a report to the chairman of the Committee on Standards on every topic which has been referred to the committee for consideration during the year.

MR. ADAMS:— My remarks were of a general nature. I might have applied them to the Executive Committees as well as to the standing committees. The question is one of policy with our Association. The work which goes to the Committee on Standards should be reduced so as to raise its quality. In other words give the standing committees a greater standing as far as their work is concerned. We have gradually elevated the work of the Association and it is along this line we can still improve it.

MR. SCHREIBER:— It is true that the Executive Committee instructed the standing committees to make definite reports on the topics assigned, but I think it should be explained that the standing committees have the responsibility of their reports. Reports should not include recommendations for "Standard" or "Recommended Practices," unless in the standing committee's opinion it is fully warranted. Such action is just as proper as it is for the standing committees to fail to give consideration to any of the subjects assigned due to lack of proper time, or for any other valid reason.

MR. LITCHFIELD:— I am not criticizing what has been done in the past. The situation is this: This being an organization of electric railway companies, we shall have to obtain the approval of a majority of the executives for the adoption of any Standards. There are in this room at the present time probably 120 men, representing presumably that many different companies, and yet in the past year we have received replies to our letter ballots from only 50 member companies. That is why I am firm in making the plea that we adopt as Standards only those things which will strike the executives of our companies as being matters proper for standardization.

Mr. Adams:— Mr. President, while we are on this question of "Standards," I desire to make a statement which I think will be of interest to the members; that is, with reference to the question of printing the "Standards" of the Association. There has been considerable question as to the best way of handling this, and in discussing this matter with Mr. Litchfield and Mr. Donecker, who have this matter in hand, we have about come to the conclusion that the most desirable way to print these specifications for the use of members, will be to have them printed in loose leaf form, so that each year the new "Standards" or "Recommended Practices," can be added and thus keep your volume up to date and take care of revisions. Some method of this character is under way at present, so that in the future we will be able to have our Standards in such a form that we can use them.

Mr. Kelsay:— We have passed over a matter on page 376, pertaining to the Specifications for Couplers on Interurban cars where the Interchange of Equipment is Involved, which I think should receive further attention. Mr. Richey suggested that we ought to embody the M. C. B. specifications for the equipment there referred to. In other words, we specify that certain parts shall meet the M. C. B. requirements. I think the M. C. B. specifications there referred to ought to be printed as an appendix to this report and will prove very valuable. I will move to this effect.

(Motion seconded and carried.)

Mr. Phillips:— I do not happen to have the M. C. B. specifications for couplers at hand, but they can be provided the Secretary if he so wishes.

President Ackerman:— Gentlemen, I am sure that we all recognize the very high degree of the work that has been carried on by the Committee on Standards, and I will entertain a motion that the report as a whole be accepted and the Committee extended our hearty thanks for their efficient services.

MR. RICHEY:— I make a motion that the report of the Committee on Standards be accepted as a whole and that a vote of thanks be extended to the members for their services.

(Motion duly seconded, stated, and carried unanimously.)

MR. PALMER:— I would like to make a motion that the Executive Committee of the Engineering Association be requested to bring to the attention of the American Electric Railway Association the difficulties which the Engineering Association has met with, with regard to securing action on letter ballots for Standards and Recommended Practices, to see if something cannot be done to remedy the trouble.

(Motion duly seconded, stated, and carried.)

PRESIDENT ACKERMAN:— We will now pass to the next report which is that of the Committee on Power Generation. I will ask Mr. Kelsay to come forward and present it.

MR. KELSAY:— Your Committee on Power Generation had assigned to it eight subjects. All of the subjects were of such importance and magnitude that it seemed impossible for the Committee to handle them and do them justice. The Committee therefore selected the first four subjects named by the Executive Committee:

(1) Methods of Selecting Faulty High Tension Cables at the Power House;

(2) Chemical Laboratory Practice in Connection with Power Work;

(3) Peak Loads;

(4) Boiler Settings and Furnace Design with Special Reference to Power Plants Built on the Common Main Basis or unit Plan Basis.

REPORT OF COMMITTEE ON POWER GENERATION

To the American Electric Railway Engineering Association:

GENTLEMEN.— Your Committee on Power Generation received instructions through the Secretary that the Executive Committee had assigned the following subjects for its consideration:

(1) Methods of selecting faulty high tension cables at the power house.

(2) Chemical laboratory practice in connection with power work.

(3) Peak loads.

(4) Boiler settings and furnace design with special reference to power plants built on the common main basis or unit plan basis.

NOTE.— The above subjects to be the main consideration of the Committee; the following subjects to receive attention in addition if possible.

(5) The possibilities of the gas engine as a power generator in the immediate future, with special attention to the limitations in size imposed by present conditions and development.

(6) The possibilities of gas producers for

(a) Anthracite coal,

(b) Bituminous coal.

(7) The best arrangement of automatic relays and other switching apparatus to protect power plants from shut downs.

(8) The application of distant control principle to all important valves in the power plant, with reference to concentration of control in some point of the plant remote from the possibilities of damage.

The first Committee meeting was held in Pittsburgh on March 25, 1912. The members present at this Committee meeting being G. H. Kelsay, *Chairman,* W. H. Sawyer, C. A. Hobein, L. P. Crecelius, and B. F. Wood.

Mr. B. F. Wood was unanimously appointed Vice-Chairman and Secretary of the Committee.

The first matter of business was a general discussion of the subjects assigned to the Committee by the Executive Committee. The decision reached was that the number of interesting subjects assigned was too great for the Committee to properly handle this year, and that it would be best for the Committee to confine their work to the first four above mentioned subjects, which were assigned to Subcommittees as follows:

(1) Methods for Selecting High Tension Cables at the Power House, to Messrs. Sawyer and Von Phul.

(2) Chemical Laboratory Practice in Connection with Power Work, to Messrs. Hobein and Gates.

(3) Peak Loads, to Messrs. Wood and Dyer.

(4) Boiler Settings and Furnace Design, to Messrs. Crecelius and Wolff.

It was decided that the subject of Boiler Settings and Furnace Design should be considered without reference to power plants built on the common main or common unit basis.

The second Committee meeting was held at the Association Headquarters in New York on June 3, 1912. There were present at this meeting Messrs. G. H. Kelsay, *Chairman,* B. F. Wood, *Vice-Chairman and Secretary,* L. P. Crecelius, W. H. Sawyer.

There was present in addition to the above Committee members, Mr. A. B. Stitzer of Ford, Bacon & Davis, who assisted Mr. Sawyer in preparing the outline of report that Mr. Sawyer as Co-chairman prepared on the subject of Method of Selecting Faulty High Tension Cables at the Power House.

At this meeting the various papers under preparation were read and discussed with the exception of the work of Messrs. Hobein and Gates, and the Committee was assured that Mr. Hobein had his subject thoroughly in hand. On account of the illness of Mr. B. F. Wood, Messrs. Wood and Dyer were unable to finish their report on Peak Loads, but it was hoped that they would be able to present to the Association a supplementary report on the subject they had under preparation.

At this time Mr. Crecelius has not completed important tests which have to do with the report on the subject of "Boiler settings and furnace design," which he and Mr. Wolf have under consideration, and it therefore becomes necessary to permit that Subcommittee to submit its report as a supplement to this report.

The reports of the Subcommittees, along with their exhibits, are herewith submitted as appendices to this report.

Respectfully submitted,

G. H. Kelsay, *Chairman,*
B. F. Wood, *Vice-Chairman,*
W. H. Sawyer,
A. Wolff,
L. P. Crecelius,
Wm. Von Phul,
C. A. Hobein,
R. A. Dyer,
C. L. Gates,
Committee on Power Generation.

APPENDIX A

METHODS OF SELECTING FAULTY HIGH TENSION CABLES AT THE POWER HOUSE

PAPER BY MESSRS. W. H. SAWYER AND WM. VON PHUL

In order to ascertain the present practice of selecting faulty high tension cables, a letter was sent to a number of companies operating large power plants in the Eastern and Middle States.

The replies indicate that a considerable number of the companies have not even taken advantage of the developments of the art and have not to-day as satisfactory methods of selection as they should and could have. Others have methods fairly satisfactory for their own local conditions but the replies in general plainly show the real need of further development of new ideas and apparatus to meet the need of many who have tried but have failed to secure satisfactory selection suited to their operating needs.

GROUND DETECTORS

"We use ground detectors" was an answer given by a number of the smaller companies, some of whose operating conditions were such that the answer showed that they did not appreciate the value of a real selective method. While electrostatic ground detectors will often indicate a weakening of the insulation before the current increases to a destructive amount, they do not, however, indicate or select the faulty cable and their use is limited to systems operated without the neutral grounded.

TORCHIO–VARLEY SYSTEM

The Torchio–Varley System, based on the principle of relative phase insulation resistance to ground, will indicate the feeder in which a fault occurs provided the feeders are not operated in parallel, in which case it will only indicate the group of which the faulty cable is one. This system has been previously fully described and is applicable only to underground cables and cannot be used with a grounded neutral. It has been very successful on high tension underground systems of 6,600 volts where the high tension feeders are not operated in parallel.

RELAYS

Overload relays of various types are in very general use for both overhead and underground feeders. At the time they were installed, they were in many cases the best that could be obtained and certain of these types properly located and set are in general fairly successful in selecting a faulty cable where there is a fault to ground with the neutral of the system grounded but where there is a "short"

between phases, such relays are in some cases absolutely unsatisfactory and in many other cases they cannot be depended on for actual selection.

It would appear that where two or more feeders are operated in parallel, either with or without grounded neutral, that the faulty (either grounded or short circuited) cable could be selected by means of inverse time element overload relays, having characteristics between the ordinary inverse time limit and definite time limit relays, on the generator end of the cables and satisfactory reverse current relays on substation or receiving end of the cables. Alternating current reverse current relays up to the present have been in general most unsatisfactory being inoperative on low power factor loads, such as are due to accidental conditions, and very liable to trip the breaker on direct overloads. Reverse current relays to be satistactory should operate practically instantaneously on a reversal of power only, not on overload, and should not operate on slight reversals such as might be occasioned by throwing a rotary on the line slightly out of phase. If such a reverse current relay did not actually select the faulty cable it should at least indicate that it has operated on a reversal of power, so that the faulty cable of a group would be immediately indicated, in the event of the entire group being cut out of service.

Relays are not endowed with human instinct and are only selective under the conditions for which they were designed and installed and in too many instances the actual conditions are different than those assumed after a too brief study. To properly select by relays, reverse current or otherwise, detailed careful study of "local conditions" must be made and *with* a satisfactory reverse current relay there is no condition which cannot probably be met *if* those conditions are understood and anticipated in the design and installation. Relays which really were selective would probably be the ideal solution as a selective relay should prevent other than the faulty cables from going out, but the weakness of the relay solution has been and is to-day the fact that operating conditions arise which were not anticipated when the relays were installed, and unfortunately, these abnormal operating conditions often occur at just the time that quick and positive selection is most needed.

Mertz–Price System

The so called Mertz–Price system and most of its modifications are based on the principle of balancing the currents at the two ends of the apparatus to be protected and the system as developed cannot be used without pilot wires, two wires per cable for magnetic balance and one wire per phase per cable for e. m. f. balance. On a large system the cost of pilot wires installed is so excessive as to limit if not prohibit its general use. This general scheme or its modifica-

tions will, however, select and isolate the faulty cable under practically all conditions of service, such as underground and overhead cable systems operated with or without the neutral grounded and with any number or combination of feeders. It is especially suited to the selection of faulty high tension tie line cables, between two generating stations or between two substations each supplied directly from common source. This system has been in use in England and on the continent for more than two years.

Stott's Suggestion

Mr. H. G. Stott has suggested a scheme which apparently will solve his difficulties when it is installed and which also serves the purpose of making this report worth while. By using overload relays he has encountered little delay from grounds but has had much more serious delays after short circuits which have taken out a large number of cables or possibly whole stations. He does not seek in this scheme to prevent the cables from going out on short circuits but does expect to save the long delay in ascertaining just which cable or cables are faulty. The one limitation of his scheme is that the main station should have a double bus but otherwise it is applicable to all conditions heretofore mentioned and the cost will be moderate. Mr. Stott's suggestion is to install in the main station where they have a double bus bar, a three-phase power transformer with a ratio of approximately 1 to 1 with high reactance and poor regulation so that the short circuited current is but little in excess of its capacity and with a k. v. a. rating somewhat in excess of the charging capacity of the longest cable connected to the system. To select the particular cable at fault, when all or a number of the cable switches have gone out, it is only necessary to connect one end of this transformer to the high tension bus bar in service and the other end to the duplicate high tension bus bar not in service and then connect, one at a time, the cables, the conditions of which are doubtful, to the high tension bus bar which is energized through this transformer. This applies full voltage to all phases of the cable simultaneously and the condition of the cable will be indicated by ammeters connected in the circuit. Each cable after being tested and found satisfactory can be connected to the bus bar supplying normal service. Such a test can be applied by the switchboard operator without leaving his station and requires but a few minutes to complete with a minimum interruption to the service.

Conclusions in General

(1) Present methods of selecting faulty high tension cables are inadequate.

(2) Ground detectors do not satisfactorily select or indicate.

(3) The Torchio–Varley and several other systems and schemes not herein described meet at the best only detail local conditions.

(4) Relays never have handled all conditions satisfactorily but the prospect of their doing so is considerably more promising to-day than ever before and we hope that this report will be the means of stirring up increased activity along this line.

(5) Modifications of the Mertz–Price system give the desired results but the cost is too high for general use.

(6) Stott's suggestion gives us a new practical quick method of "selecting faulty high tension cables at the power house," at moderate cost and is applicable to practically all conditions of operation.

(7) This report has purposely been made very brief and does not purport to cover all methods either now in use or proposed, but will have served its purpose if even only a few of those interested will realize that in many cases valuable time is now being *unnecessarily* wasted due to the fact that there are not in use satisfactory "Methods of Selecting Faulty High Tension Cables."

APPENDIX B

CHEMICAL LABORATORY PRACTICE IN CONNECTION WITH POWER WORK

PAPER BY CHAS. A. HOBEIN†

This report will consider the subject from three different viewpoints, first, considering the chemical laboratory practice of companies operating large urban systems or companies operating several interurban systems who maintain a general laboratory. This class of companies employ a good chemist and test all materials.

The second consideration will be that of companies who can maintain enough chemical apparatus to make the most important tests. They can employ a student, or recent technical graduate, to devote part of his time to the work. Such companies would be those operating urban systems of perhaps 100 cars, or interurban systems of 75 or 100 miles.

The third consideration will be that of companies operating small systems who cannot afford to maintain any sort of laboratory apparatus, but who should send materials out to testing companies for reports.

This report will deal with tests of the chief materials used in power work only, namely, coal, water, and oil.

A list of questions was sent to 91 companies of all classes. These questions sought to bring out the extensiveness of the present use of the chemical laboratory in power work; the methods followed in laboratories at present in operation; the materials tested; the materials sent out for test and how often; and the proportion of the total consumption of the particular material tested or sent out for test.

Thirty-three replies were received and classified as follows; first class, 12; second class, 14; third class, 7. The following table has been arranged from the replies received and it embodies the greater part of the data received in answer to the questions.

	First Class	Second Class	Third Class
1.— Companies with laboratories	9	*0	**0
With Laboratories			
2.— Companies testing coal by following method of the American Chemical Society	2	0	0
3.— Companies testing coal	8	2	0
4.— Companies testing water	6	1	1
5.— Companies testing oil	8	0	1

* Three companies of this class have some chemical apparatus and make some tests as indicated.

** One company of this class has some chemical apparatus and make some tests as ndicated.

† This paper was assigned to a subcommittee consisting of Messrs. Chas. A. Hobein and C. L. Gates, but Mr. C. L. Gates was unable to assist in its preparation and the paper was prepared by Mr. Chas. A. Hobein.

Without Laboratories

	First Class	Second Class	Third Class
6.—Companies which have tests made of coal	2	9	1
7.—Companies which have tests made of water	1	9	1
8.—Companies which have tests made of oil	3	1	1

All Companies

9.—Companies which have hard water for boiler feed	9	13	2
10.—Companies which treat water outside of the boilers	1	3	0
11.—Companies which do not test any materials or have any tested	0	0	***4
12.—Number of replies received	12	14	7

This report will now take up the work as outlined and show the methods used by different companies, together with such comments and suggestions as may be pertinent to the subject.

Companies of the First Class

The companies of this class, which maintain laboratories, employ good chemists and do testing for all departments.

The materials tested in connection with power work are: coal, water, oil, pipe covering material, condenser tube material, cement, fire clay, babbitt, lead, rubber, etc.

One large company, with a very complete laboratory, does testing for outside parties and has issued a list of their charges for making tests. It tests all materials used in manufacturing processes and even does gold and silver assaying.

One company purchasing coal, on the basis of chemical analysis, does not maintain a laboratory.

Coal

As will be noted from the table only two companies of this class, from whom replies were received, follow the method of coal analysis as outlined by the American Chemical Society.

Conditions, varying with different localities, often make it desirable for laboratories to adopt their own methods for analyzing coal, the methods followed, being more adapted to their needs than those outlined by the American Chemical Society. When conditions warrant, it is reasonable practice to depart from the above mentioned method as much as desired.

***Three companies of this class are buying water power and only one of the three maintains a reserve steam plant.

Whenever two or more laboratories are running an analysis on the same coal, it is desirable and essential that they follow the same method in analyzing the sample. This is illustrated, by a comparison of results obtained, in determining ash, by the method followed by the United Railways Company of St. Louis and the method recommended by the American Chemical Society. The method followed by the Railways Company gives a lower percentage of ash than the Chemical Society method.

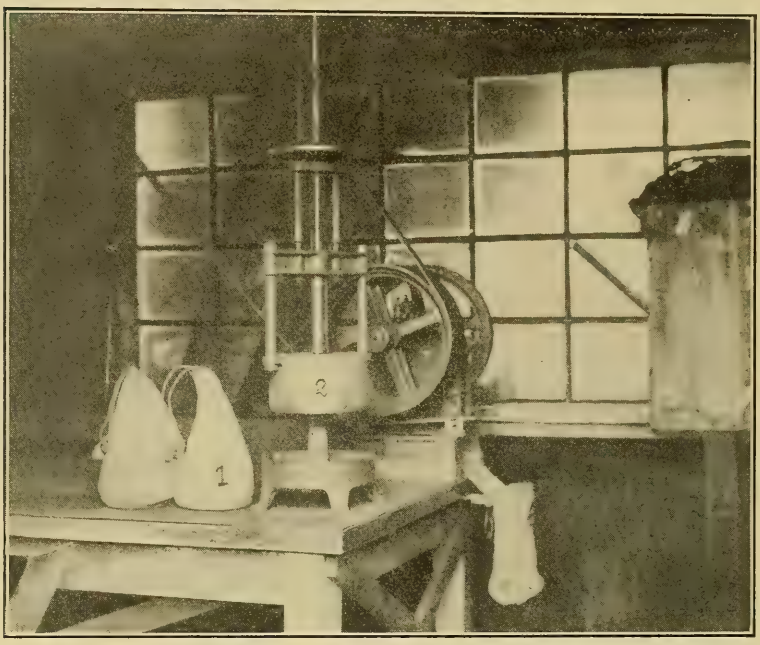

FIG. 1. SHOWING LABORATORY OF THE UNITED RAILWAYS COMPANY OF ST. LOUIS.

No. 1. Coal samples as received from the power plants.
No. 2. Pulverizer.
No. 3. Braun chipmunk crusher.

The method of analyzing coal used in the laboratory of the United Railways Company of St. Louis (See Exhibit I) has a number of novel features. The method outlined is rapid and requires only one sample to be weighed, for the complete proximate analysis, and the burning of the sample to ash with oxygen is very rapid and quite different from other methods. A separate sample is weighed for the B. T. U. determination for which a Parr calorimeter is used. Fig. 1 shows the crusher and pulverizer used in preparing the sample for

the chemist and Fig. 2 shows the balance for weighing the materials tested as well as the desiccator.

The crushing and pulverizing equipment is very complete and is able to handle at least 16 samples per day.

The method outlined by The Cleveland Railway Company (See Exhibit II), while not particularly rapid, indicates refinement in determinations. The Atwater oxygen bomb calorimeter is used. Ash, sulphur, and B. T. U. are the usual determinations made. The American

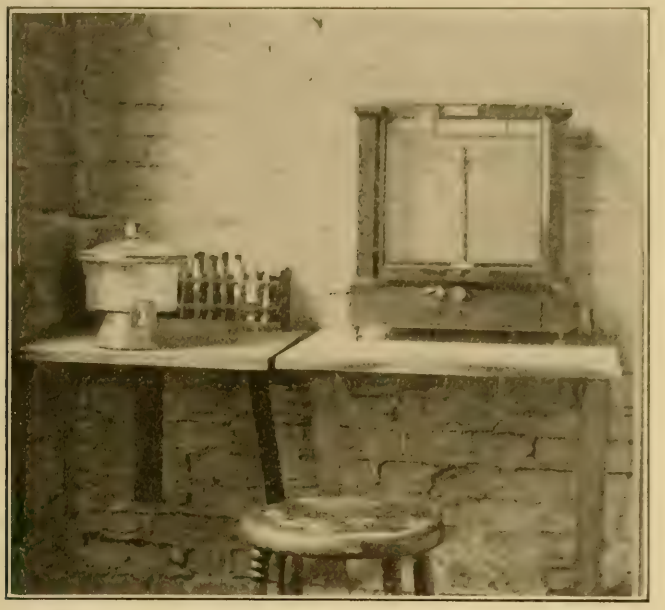

FIG. 2. LABORATORY OF THE UNITED RAILWAYS CO. OF ST. LOUIS.

No. 1. Desiccator.
No. 2. Sample rack with coal samples.
No. 3. Balance.

Chemical Society methods are closely followed in determining volatile, fixed carbon, moisture, and ash. The company uses a water jacketed drying oven, which is a great help in maintaining a constant drying temperature.

The methods of the Detroit United Railway (See Exhibit III) are mostly standard methods, except that a large sample is used in determining moisture. Heat value or B. T. U., moisture, and ash are the usual determinations made. The Atwater bomb calorimeter is used.

The methods of coal analysis, as followed by the Public Service Railway of Newark, N. J. (See Exhibit IV) are very similar to the methods outlined by the other companies. The Emerson oxygen bomb calorimeter is used.

The methods used by the Washington Water Power Company of Spokane, Wash. (See Exhibit V) are quite different from the usual methods. This company has adopted special apparatus to suit its individual requirements. They have a special oxidizing furnace and use clay crucibles. The samples that are used to determine the different constituents are several times larger than ordinarily used. The scheme for determining volatile matter is quite distinctive. The Parr calorimeter is used.

In connection with the determination of volatile matter, some companies use platinum crucibles of 30 grams weight, some of 10 or 15 grams weight, and others use a hard clay crucible. The time of heating the sample also varies. These different conditions make it impossible for the different laboratories to obtain the same result on the same coal. The government, through the Bureau of Mines, has issued a bulletin on Methods of Analyzing Coal and Coke, which states, in reference to the determination of volatile matter, that: "It should be clearly understood that the volatile matter so determined, does not represent any definite compound in the coal. The method of determination is wholly conventional, and any variation in temperature, or rate of heating, will change the amount of volatile determined." Thus it is evident that the main idea for any laboratory, in comparing the different coals, is to follow that method which allows them to obtain results suitable to their own needs.

For the determination of the heating value of the coal there are several types of calorimeters available and at present there is quite a difference of opinion regarding the merits of these several types. It is hardly within the province of this Committee to make a decision regarding the respective merits of the various types. A contract for coal on the B. T. U. basis, should state the type of calorimeter to be used for making the determination, and it should also specify that all check tests be run on the same type of calorimeter and that the same weight of sample be used.

There are two types of calorimeters in use at the present time and both are of the bomb type, that is, the coal is burned inside a sealed bomb. In one type which is represented by the Mahler and Emerson oxygen bomb calorimeters, the combustible is burned in the presence of oxygen under pressure. The other type is illustrated by the calorimeters of Parr and Roland Wild and use sodium peroxide to burn the coal.

Both of these types of instruments have their bad features. The Parr calorimeter is very well suited to obtaining results suitable for the purchase of coal on the heat unit basis, but requires a fair degree

of skill to obtain accurate results with it, although it is much more an instrument for everyday use than an oxygen bomb calorimeter. In using the instrument it is perhaps advisable to make use of a standardized Beckmann thermometer, for with this type of thermometer the temperature rise during combustion can be more accurately determined.

The oxygen bomb type of calorimeter should only be used where expert attention can be given to its manipulation. In mentioning some of the drawbacks of this type of calorimeter an article, under the caption "Coal and Common Sense," by Jacques Abady, which appeared in the *Electrical Times* September 7, 1911, will be quoted. "An excessive pressure of oxygen is likely to lead to incorrect results as it has a tendency to cause unburned fuel to be left in the calorimeter. The temperature difference is small, and the temperature requirements of the room in which it is used require, therefore, great attention. It gives heat value at constant volume, whereas in practice, combustion takes place at constant pressure, and the difference in the calorific values under these conditions, therefore, cause an error in the value given by the calorimeter."

As a matter of fact both of these types of instruments are in extensive use in the United States by electric railway and associated companies, for determining the calorific value of fuel. Calorimetric work calls for careful manipulation, no matter what type of calorimeter is used, and if in doubt as to the accuracy of the results derived, a check can be obtained with the standards furnished by the National Bureau of Standards.

WATER

There are two methods of water analysis which can be used, the gravimetric and the volumetric method. In the gravimetric method everything is determined by weighing after the substances have been precipitated or otherwise separated. The volumetric method is one in which the constituent of a sample is determined by allowing a solution of known composition to react with it either directly or indirectly. Knowing the volume of the solution used, the amount of the constituent can be computed by means of the laws of chemical equivalents.

In the methods accompanying this report, a combination of both methods are used. The gravimetric method is the more accurate but it is much the slower method. For the analysis of boiler water the volumetric is accurate enough.

In addition to the methods of water analysis published in this report (see Exhibits VI and VII), there are two methods given in *Engineering Chemistry* by T. S. Stillman. These will be found in the second edition, 1900, pp. 44 and 53. The methods are arranged in tabular form and show very clearly the work as carried out step by step.

The greatest divergence in water analysis work occurs in reporting results. A sample of water may be sent to two different chemists and as a result their reports apparently indicate that they are not reporting on the same water. This difficulty occurs because of the fact that while the chemist is able to determine the substances which occur, in their ionic form, he is not able to tell exactly how these substances are combined as there is no standard method of combining the elements. As an example, examine the methods which follow. These three methods are fairly standard and each has its champions.

Hypothetical Combinations of the ions found in Water Analysis. All report silicia as SiO_2, iron and aluminium as Fe_2O_3, and Al_2O_3.

First method: Combine the chlorine first with potassium, then with sodium, any excess with magnesium, then with calcium.

Combine the sulphate first with calcium, then with magnesium and any excess with sodium.

Combine any residual bases to carbonates.

Second method: Combine in the following order:

Basic.
Potassium.
Sodium.
Magnesium.
Calcium.
Acidic.
Chlorine.
Sulphuric.
Residual bases to carbonates.

Third method: From the alkalinity combine the carbonate radicle, first to calcium, then if in excess to magnesium, any excess carbonate to sodium. Then combine any excess calcium to calcium sulphate and if there is any excess calcium still remaining to calcium chloride. Should there still be an excess of sulphate, from the calcium ion, combine it first with magnesium, then with sodium and any excess chlorine with any magnesium left from above and any further excess of chlorine from above to sodium chloride.

Quoting now, from a government publication of the Geological Survey, Document No. 232 of the House of Representatives of the 59th Congress, 1st session. Water Supply and Irrigation Paper No. 151 Series L, Quality of Water 11. The paper entitled, Field Assay of Water, by Marshall O. Leighton, as follows: "Another error arises from the conventional method of expression of results. If the analyst finds that the water contains certain amounts of Ca, Mg, Na, and K, and certain equivalents of the carbonate, sulphate, and chloride radicals, he unites these substances according to methods which are, apparently, not uniform and entitled to little scientific justification. It is a well known fact that if several chemists each independent of every

other, analyze a certain water there will almost invariably be wide differences in the expression of results.

Dr. F. W. Clark, Chief Chemist of the United States Geological Survey, in a recent communication has given an excellent illustration of the various hypothetical combinations which may be made, of the results of a single analysis of water. Each series of combinations is based upon a generally accepted hypothesis and each represents a water that is totally different from the others."

TABLE I — ANALYSIS OF WATER FROM ARTESIAN WELL AT MACOMB, ILLINOIS *

(Grams per liter)

Statement in ionic form		Statement according to hypothetical combinations				
SiO_2	0.0105	KCl	.....	0.0452	0.0181	0.0211
Al_2O_3	0.0013	NaCl	0.8968	0.8384	0.7164	0.8172
Fe_2O_3	0.0023	$CaCl_2$	.....	.....	0.0877	0.0292
SO_4	0.9991	$MgCl_2$	.....	0.0154	0.0571	0.0242
CO_3	0.3953	K_2SO_4	0.0528	.....	0.0211	0.0246
Cl	0.5418	Na_2SO_4	0.4649	1.4781	1.2495	1.0642
Na	0.8086	$CaSO_4$	0.5450	.....	0.1218	0.2223
K	0.0237	$MgSO_4$	0.3360	.....	0.0711	0.1357
Ca	0.1581	K_2CO_3	.....	.....	0.0084	0.0028
Mg	0.0672	Na_2CO_3	0.6983	.....	0.2793	0.3259
		$CaCO_3$	.....	0.3952	0.2278	0.2076
		$MgCO_3$	.....	0.2215	0.1355	0.1190
		Al_2O_3†	0.0013	0.0013	0.0013	0.0013
		Fe_2O_3†	0.0020	0.0020	0.0020	0.0020
		SiO_2†	0.0105	0.0105	0.0105	0.0105
			3.0076	3.0076	3.0076	3.0076

* By Geo. Steiger, Lab. U. S. Geo. Survey.

† Al_2O_3, Fe_2O_3, SiO_2 conventionally regarded as colloidal.

To express the above in parts per million or (milligrammes per kilogram), multiply the results given by 1,000.

There are 1,000 milligrammes per gram and one liter of water weighs approximately one kilogram.

Quoting now from an article which appeared in the *Engineering News*, Vol. 60, 1908, page 355, on The Mineral Analysis of Water for Industrial Purposes and its Interpretation by the Engineer, by Herman Stabler: "Recent practice among water analysts tends toward the statement of analysis in ionic form, in parts per million and the abolition of the statement in grains per gallon, of mineral salts, supposed to be present." The author then develops formulae by means of which the analysis, when expressed in ionic form, may be interpreted to be of use to the engineer. These formulae derive results which indicate the amount of scale which the water will form, the amount of forming which is likely to occur, the liability to pitting, and the quantity of chemical needed to properly soften the water.

In view of the foregoing, it is the recommendation of this committee that the results of all water analysis be expressed in the ionic form, in parts per million. Attached as part of this report is a table

of solubilities of various substances and a table for converting grains per U. S. gallon to parts per million, or what is the same thing milligrams per kilogram.

TABLE II — TABLE OF SOLUBILITIES*

(Quantity of substance that one U. S. gallon of pure water can dissolve)

SUBSTANCE	At 60° F.	At 212° F.
Alum (potash alum)	0.792 lb.	29.82 lb.
Aluminium sulphate	2.75 "	7.42 "
Ammonium oxalate	0.376 "	3.4 "
Barium chloride	2.92 "	5.01 "
" hydrate	0.416 "	0.835 "
Calcium carbonate**	2.083 grains	1.25 grains
" chloride	33.35 lb.	Unlimited
" hydrate	77.5 grains	44.65 grains
" nitrate	33.35 lb.	Unlimited
" oxide (lime)	58.35 grains	33.8 grains
" sulphate†	134.10 "	126.8 "
Ferrous sulphate	1.666 lb.	14.85 lb.
Magnesium carbonate	Doubtful	1.25 grains
" chloride‡	16.66 lb.	33.35 lb.
" hydrate	1.666 grains	1.666 grains
" oxide	1.169 "	1.169 "
" sulphate	2.49 lb.	10.83 lb.
Sodium biborate (borax)	3.335 "	4.59 "
" carbonate (dry)	1.00 "	3.76 "
" carbonate (crystals)	3.42 "	11.69 "
" chloride	2.92 "	3.34 "
" hydrate	5.08 "	Unlimited
" hyposulphite	4.17 "	16.66 lb.
" phosphate	1.00 "	16.66 "
" sulphite	2.08 "	8.35 "
" sulphate	0.918 "	3.5 "

* " Boiler-waters,"— By Wm. W. Christie.
† Decomposes at boiler temperatures in presence of alkaline earths or iron.
‡ Insoluble at 302° F., equal to 70 lb. steam pressure.
** Insoluble at about 290° F.

TABLE III — CONVERSION OF MILLIGRAMMES PER KILOGRAMME INTO GRAINS PER U. S. GALLON OF 231 CUBIC INCHES *

(One U. S. gallon of pure water at 60° F. weighed in air at 60° F., at atmospheric pressure of 30 in. of mercury, weighs 58,334.94640743 grains †)

Parts per million	Grains per U. S. gallon	Parts per million	Grains per U. S. gallon	Parts per million	Grains per U. S. gallon
1	0.058335	36	2.100058	71	4.141781
2	0.116670	37	2.158393	72	4.200116
3	0.175005	38	2.216728	73	4.258451
4	0.233340	39	2.275063	74	4.316786
5	0.291675	40	2.333398	75	4.375121

* Examination of Water. Wm. P. Mason. (Boiler-waters) Wm. W. Christie.
† See article by Mason on The U. S. Gallon in *American Druggist*, January, 1888.

TABLE III.—CONVERSION OF MILLIGRAMMES, ETC.—(*Continued*).

Parts per million	Grains per U. S. gallon	Parts per million	Grains per U. S. gallon	Parts per million	Grains per U. S. gallon
6	0.350010	41	2.391733	76	4.433456
7	0.408344	42	2.450068	77	4.491791
8	0.466679	43	2.508402	78	4.550126
9	0.525014	44	2.566737	79	4.608461
10	0.583349	45	2.625072	80	4.666796
11	0.641684	46	2.683407	81	4.725130
12	0.700019	47	2.741742	82	4.783465
13	0.758354	48	2.800077	83	4.841800
14	0.816689	49	2.858412	84	4.900135
15	0.875024	50	2.916747	85	4.958470
16	0.933359	51	2.975082	86	5.016805
17	0.991694	52	3.033417	87	5.075140
18	1.050029	53	3.091752	88	5.133475
19	1.108364	54	3.150087	89	5.191810
20	1.166699	55	3.208422	90	5.250145
21	1.225034	56	3.266757	91	5.308480
22	1.283369	57	3.325092	92	5.366815
23	1.341704	58	3.383427	93	5.425150
24	1.400039	59	3.441762	94	5.483485
25	1.458373	60	3.500097	95	5.541820
26	1.516708	61	3.558432	96	5.600155
27	1.575043	62	3.616766	97	5.658490
28	1.633378	63	3.675101	98	5.716825
29	1.691713	64	3.733436	99	5.775159
30	1.750048	65	3.791771	100	5.833494
31	1.808383	66	3.850106		
32	1.866718	67	3.908441		
33	1.925053	68	3.966776		
34	1.983388	69	4.025111		
35	2.041723	70	4.083446		

OIL

The methods of testing and analyzing oils are fairly well standardized and the methods followed in the laboratories of two companies are incorporated herewith.

There are several types of viscosimeters in use and it is impossible to get comparative results with this piece of apparatus, not alone between instruments of different makes, but with instruments of the same make. This is not a serious defect, for what is wanted in any case is only a comparison between the delivered oil and the oil of the guaranteed grade. If it is desired to compare an oil furnished to another company with an oil being used in one's own service, the simple expedient is to secure a sample and run it on one's own viscosimeter. The viscosimeter shown in Fig. 3 is one built by the United Railways Company of St. Louis and is similar to the type used by the Standard Oil Company. Its advantage lies in the simplicity and in the fact that the oil cup is surrounded by a comparatively large quantity

of water, which makes it an easy matter to keep the oil at a constant temperature. The instrument is very easily cleaned. Two of these instruments are used in the laboratory, one for running the heavy cylinder oils and the other for the light oils. The cylinder oils

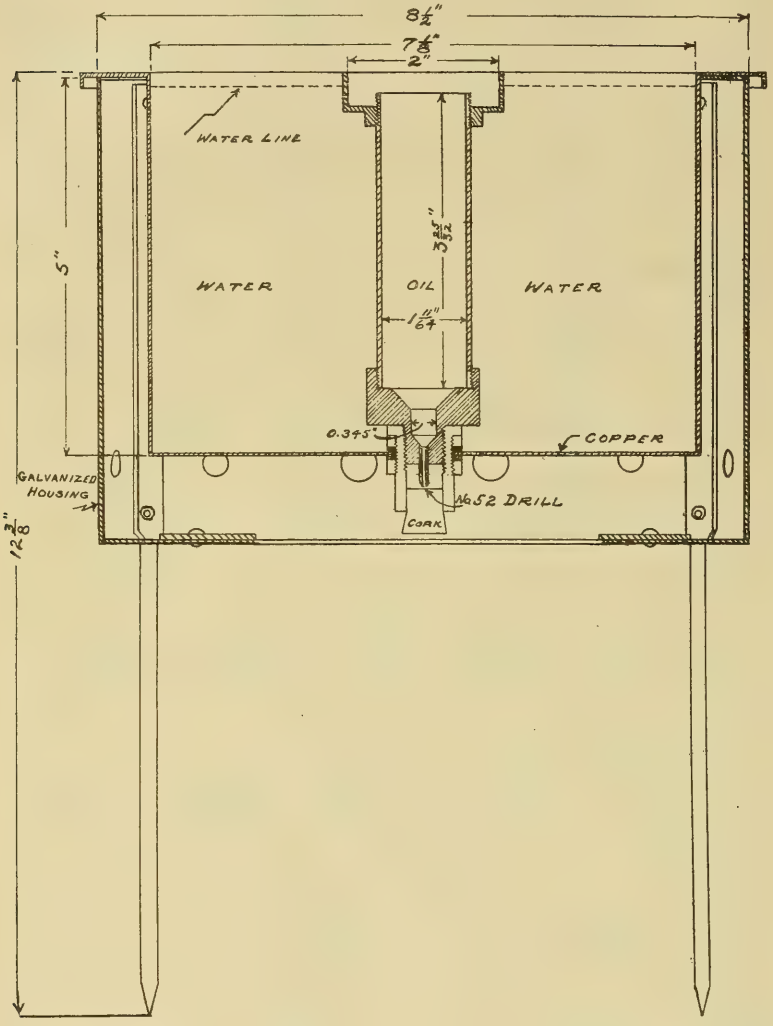

Fig. 3. Showing Viscosimeter as Made and Used by the United Railways Company of St. Louis.

are heated to 212 deg. Fahr. and the light oils to 100 deg. Fahr. Fig. 4 illustrates the entire oil testing apparatus used, and Fig. 5 shows the Cleveland fire tester cup for obtaining the flash and fire temperatures.

In answering the questions sent out in regard to oils many companies replied that the only tests made on oils were service tests. While it cannot be denied that service tests are perhaps the only tests that will select an oil suitable for the service, still after having made

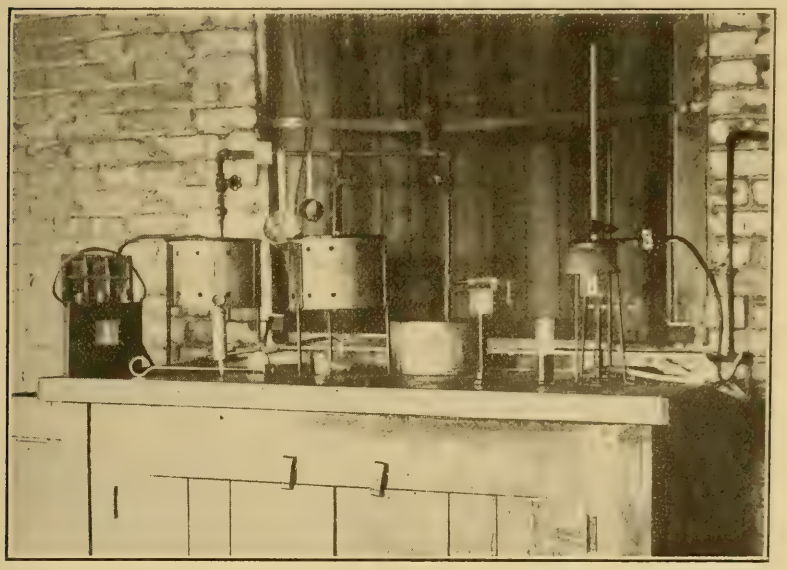

FIG. 4. SHOWING LABORATORY OF THE UNITED RAILWAYS COMPANY OF ST. LOUIS.

No. 1. Samples of oil as received from the power stations.
No. 2. Viscosimeter for running heavy oil.
No. 3. Viscosimeter for running light oil.
No. 4. Bath for heating the oils preparatory to obtaining the viscosity.
No. 5. Westphal balance.
No. 6. Cleveland open fire tester.
No. 8. Test flame. Torch.
No. 9. 60 c.c. graduated flask.

the service tests and the characteristics of the oil having been determined in the laboratory, it is a simple matter to check the deliveries from time to time and determine whether oil of the guaranteed quality is being delivered. It would thus be possible to reject an inferior

oil before it had been used and possibly prevent much damage to the machinery. The simple oil tests would do this.

Some companies make use of a friction testing device, by means of which the lubricating quality of an oil can be determined. This apparatus is no doubt of value in testing oils for bearings, etc., and the conditions of service can be closely duplicated by this apparatus. The only test to determine the entire suitability of a cylinder oil, however, is to test it under actual working conditions, in the cylinder.

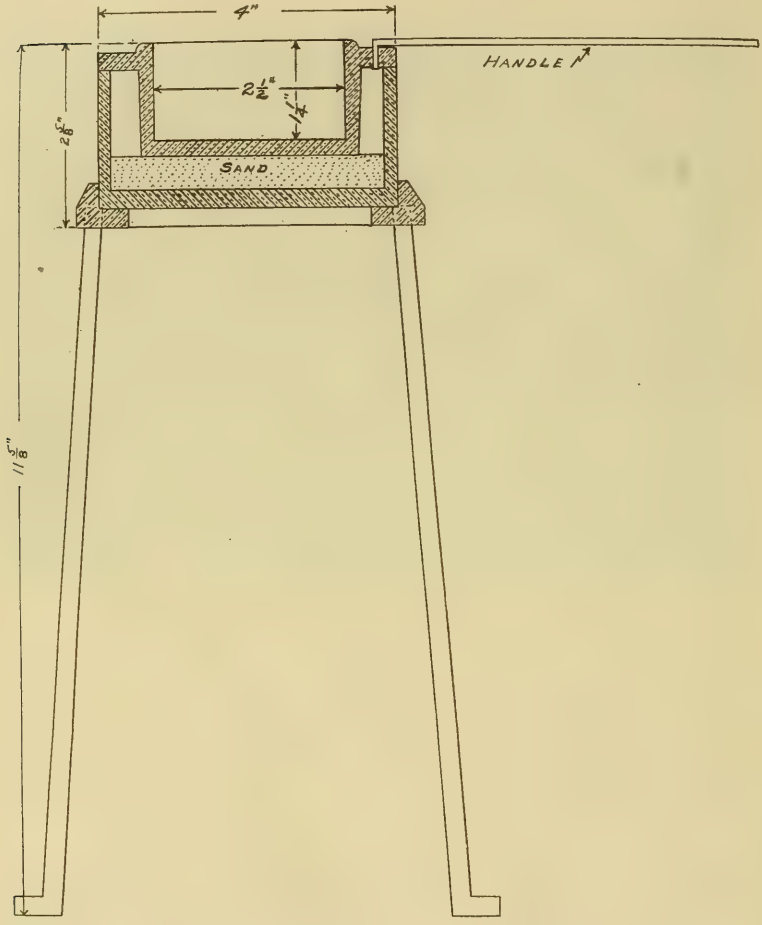

Fig. 5. Cleveland Open Fire Tester for Obtaining the Flash and Fire Temperature of Oils, as Made by and Used by the United Railways Company of St. Louis.

Companies of the Second Class

COAL

The chemical analysis of coal by companies of this class should not be difficult of accomplishment. An essential piece of apparatus is a good balance and all other apparatus, with the exception of platinum crucibles, are comparatively inexpensive. The entire proximate analysis of coal can be made, but to determine heat values it is necessary to purchase a calorimeter.

The accurate determination of the heat value of a coal calls for very careful manipulation and a careful study of all the factors which affect the successful operation of the calorimeter must be made. The apparatus should be compared with standards, obtainable from the National Bureau of Standards, which are benzoic acid and naphtholine. These materials are burned in a calorimeter at Washington and the heat value is very carefully obtained and certified to. These standards run in a calorimeter under test check the accuracy of the instrument. It is doubtful, unless a competent chemist is employed, if reliable results could be obtained.

It is possible for a company to accomplish satisfactory results, in obtaining a supply of good coal, by purchasing it upon the ash basis. In order to do this it would be necessary to have the coal from the different mines, from which purchases are made, tested for heating value which would give information regarding the value of the coal from the particular coal seam. The only factors which affect the heating value of a coal that comes from the same mine continually, are moisture and ash. The chemical constituents, such as sulphur, volatile, and fixed carbon, remain practically constant and by specifying the allowance of ash per pound of dry coal, approximately the same result is accomplished as by buying the coal where the B. T. U. is specified. This plan works out very well in contracts with individual mines. The buyer must know that all deliveries furnished under the contract, come from the mine on which the contract was based. The determination of ash and moisture, in a sample of coal, are comparatively simple. The methods as outlined, under the methods of coal analysis, in the first part of the report indicate clearly the simplicity.

It is possible to estimate the B. T. U. per pound of coal with a fair degree of accuracy, when the volatile matter and fixed carbon are known. By means of the curve and formula accompanying this report (Fig. 6), the B. T. U. can be determined within about 2 per cent. This curve was originally published in the *Wisconsin Engineer* and republished in *Power* of April 16, 1912, Vol. 35, No. 16. The values of volatile matter and fixed carbon are each in per cent. per pound of coal as received.

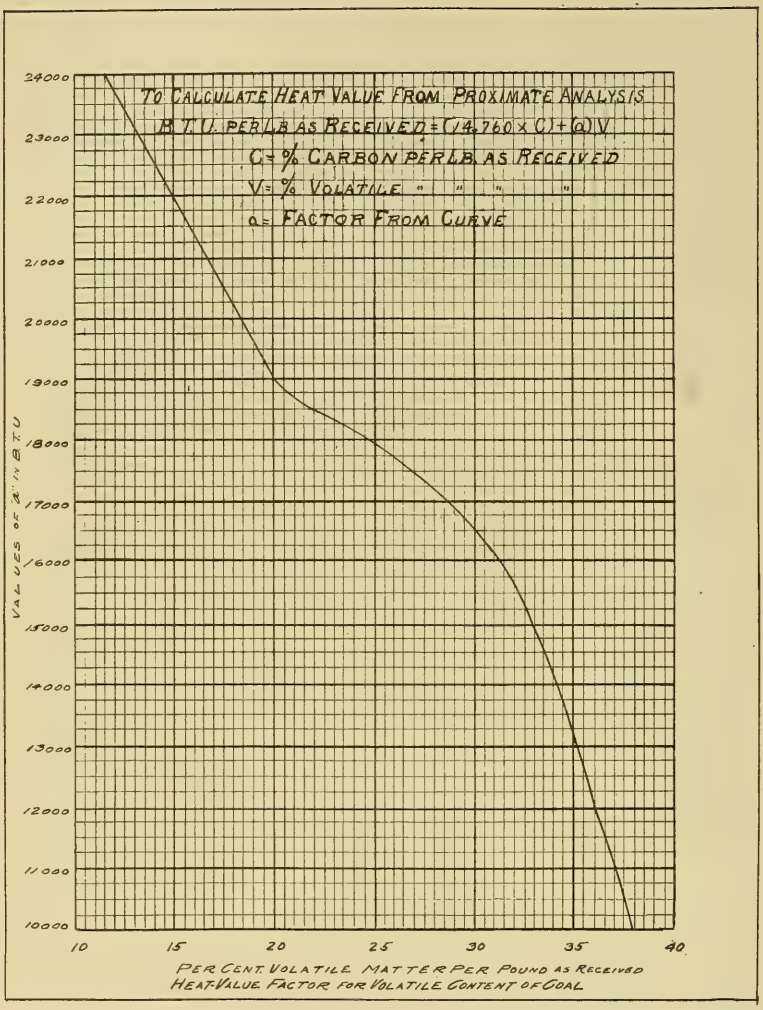

FIG. 6. SHOWING CURVE FOR ESTIMATING THE B. T. U. PER LB. OF COAL FROM THE PROXIMATE ANALYSIS OF COAL AS RECEIVED.

WATER

The chemical analysis of water is quite an exact method and it is doubtful if it would be possible for any but an experienced chemist to carry the analysis through and obtain accurate results; however, it is not necessary to make a complete analysis of water except at fairly

long intervals. When these tests have to be made a sample of water could be sent out for analysis and these samples should call for the results in the ionic form in parts per million. With the results of the complete analysis available it would be possible for the smaller company to make tests from time to time which by comparison with the complete analysis would give an accurate idea of the condition of the water in use. These tests would be similar to those outlined in the first part of the method used in the laboratory of the United Railways Company of St. Louis. These tests are headed, "Method for Testing Boiler Water." This determines the temporary or carbonate hardness, the permanent or non-carbonate hardness and the total magnesium. Temporary and permanent hardness can be easily determined, with some waters, by means of a standard soap solution as outlined in Exhibit X.

OIL

Companies of this class should be able to carry out all of the ordinary tests on oils. These tests include the following: flash temperature, fire temperature, viscosity, gravity, and cold test and serve to detect any variation in the supply of oil being furnished, as well as being useful to compare different brands of oil. This is best illustrated by considering a hypothetical case. Suppose a company is buying a brand of cylinder oil, known for instance as Red Indian Selected Stock. The company in question, after using the oil for several years, at a price of 60 cents per gal., began oil testing and after a few months secures a sample of plain Pennsylvania steam refined stock for test. The results when compared with the oil in use, appear almost identical. The question at once arises, why would not the Pennsylvania stock at 15 cents per gal. work as well as the Red Indian brand at 60 cents a gal.? When the actual test is made in the engine cylinder, in ninety cases out of one hundred, the plain stock does the work exactly as well as the fancy brand, fancy in name only.

Companies of the Third Class

COAL

Companies of this class usually purchase their coal from one mine or at the most from two or three and by sending samples to a chemist once a year, for an approximate analysis and B. T. U. determination, the purchaser can obtain a good knowledge of the grade of coal which the mine is furnishing. The sample analyzed should be an average of the deliveries for several days and with a knowledge of the product expected, the consumer can rest assured that if the coal comes from the same mine continually the only thing which will vary the heat value of a pound of fuel, will be a variation in the percentage of moisture or ash. The chemical composition of the coal will remain practically

constant but the ash will vary due to the amount of clay and non-combustible matter which occurs in the seam of coal and still more to the methods of mining. It should be a simple matter to send a sample of the deliveries to a chemist from time to time for a check on the ash, which could be obtained for a small charge. By requesting that the report be made in percentage of ash per pound of dry coal, the variable due to moisture is eliminated and the result can be checked with the approximate analysis obtained on the yearly sampling. Suppose the approximate analysis would show

B. T. U.	Moisture.	Volatile.	Fixed Carbon.	Ash.
11,276	5.00	36.00	47.00	12.00

on a dry basis this would become

B. T. U.	Moisture.	Volatile.	Fixed Carbon.	Ash.
11,868	0.00	37.89	49.47	12.64

Suppose the ash should show, on a report from a sample sent to a chemist, 18 per cent. per lb. of dry coal. If the coal was from the same mine as the sample whose analysis is shown above, it would be safe to assume that the analysis of the coal whose ash was 18 per cent. would be as follows, calculated from the above dry basis analysis, by changing the amount of ash.

B. T. U.	Moisture.	Volatile.	Fixed Carbon.	Ash.
11,140	0.00	35.57	46.43	18.00

It would be perfectly feasible for the engineer of the power plant to obtain fair results by taking a sample of coal about 10 lb., crush it to pass through a coffee mill, spread it in a shallow pan, heat it for an hour on the breeching above the boiler where the temperature was 212 deg. Fahr. and then weigh it again. The difference in weight before and after heating would be the pounds of moisture and the relative percentage could be easily calculated.

A one-half pound portion might be finely pulverized and placed in a clay crucible on a forge and heated until the coal would be converted to ash. Thus the ash could be determined. This may be said to be a far cry from laboratory methods. This is true, but it would be the laboratory method adapted to suit the exigencies of the case and would thus be justified.

WATER

A complete analysis is required only at long intervals when there is a change in the supply or when other conditions, such as the waste from new manufacturing plants, is polluting the supply.

Chemical testing concerns will make a test for a small charge to determine the temporary hardness, or hardness which is precipitated by heat, and the permanent or sulphate hardness, or hardness which is

only precipitated in the boiler, due to concentration and heat. It seems best to recommend a check on the water supply at reasonable intervals and a complete analysis should be reported in parts per million on the ionic basis. This will insure the results being comparable no matter to what chemist the samples are sent.

Companies furnishing water purification systems have simple tests which indicate the amount of chemicals required to soften the water. These also indicate when the water has been properly treated.

OIL

Simple tests on oil can be carried on by almost any one and the apparatus is inexpensive and easily understood. It is a question with the smaller companies whether the oil requirements are large enough to justify the expense and labor of making even the simple tests which are not chemical in nature.

We wish to acknowledge the help extended by the various contributors to this report. This includes not only those whose names appear in connection with the various processes outlined, but all who responded to the questions in the circular letter as well as to the company of chemists whose aid was sought in preparing the descriptions of analytical methods used.

EXHIBIT I

METHOD USED IN THE LABORATORY OF THE UNITED RAILWAYS COMPANY OF ST. LOUIS FOR ANALYZING COAL

Apparatus for Approximate Analysis of Coal

Balance sensitive to 1/10 milligram	$65 00
Weights analytical — 50 grams to 1 milligram	15 00
8–10 gram platinum crucible with cover	15 00
Iron ring stand	75
Bunsen burner and tube	50
Oxygen cylinder	20 00
Desiccator with porcelain plate	2 00
Parr calorimeter (electric ignition)	75 00
Motor for calorimeter	5 00
Drying oven	7 50
Extra rubber and glass tubing, tongs, sample bottles, etc.	5 00
100–mesh sieve with cover	2 50
Steel mortar	2 00
Braun Chipmunk crusher	60 00
Pulverizer $60 00 or	25 00
	$300 25

APPARATUS FOR SULPHUR DETERMINATION IN COAL

2–300 c. c. beakers	$0 50
2–watch glasses	25
2–funnels	50
11 cm. quantitive filters Stirring rods 10 per cent. $BaCl_2$ solution Concentrated C. P. Hydrochloric Acid Weak solution of $AgNO_3$	5 00
Sulphur Photometer "Parr"	35 00
	$41 25
Total	$341 50

SAMPLING

Three (3) samples are taken from each car shipment by driving down a sampling ram. The ram is made from a five (5) foot length of heavy two (2) inch iron pipe sharpened at one end; the other being reinforced to allow the tube to be driven down into the coal with a heavy hammer.

These three samples, or cores, amounting to about five pounds, are sent to the laboratory for analysis. Should the sample when received at the laboratory be too moist for the pulverizer to handle, the coal is spread out on a hot plate until the moisture content is low enough to permit grinding. The sample may also be dried by spreading out on a large sheet of paper and leaving the coal exposed to the air for a few hours.

Each five-pound sample is crushed in a "Braun Chipmunk" crusher to about ¼ in. This sample is then mixed and quartered down to about one pound. If there are two or more samples from the same mine of the same kind of coal, each sack is crushed and quartered to one pound as above. The one-pound crushed and quartered samples (each one representing one car) are mixed and quartered until about one-half pound is left. The half pound is then crushed again to about ⅛ in. mesh. From the crusher the coal is put into a pulverizer. Upon going through the pulverizer once coal of about forty mesh is obtained. This sample is placed on the sampling table and well mixed. It is then spread out on the table and small portions taken from all parts of the pile with a spatula. This small sample of from 10 to 15 grams is again put into the pulverizer and ground to pass a 100-mesh sieve. The remainder of the sample is put in a tight Mason jar and kept in the laboratory for 30 days. Should a check analysis be required this sample is used.

If not all of the coal can be made to pass through a 100-mesh sieve by running through the pulverizer several times, the small amount left on the sieve is ground in a hand mortar until the required fineness is reached. The sample is then put into a bottle or test tube (which is tightly stoppered to avoid moisture change) and is ready for analysis.

A one gram portion of this 100-mesh sample is used for the approximate analysis, and another portion of 0.5 gram is used for the B. T. U. or heating value determination.

Approximate Analysis

The approximate analysis determines four (4) values, the amount of moisture, volatile matter, fixed carbon and ash.

MOISTURE

A ten (10) gram platinum crucible is weighed, putting the lid on the pan and placing the crucible on it. A one (1) gram weight is placed on the weight pan of the balance and coal sample is then added or taken from the open crucible until the balance is in equilibrium, thus introducing and weighing the one (1) gram sample used for the approximate analysis.

The crucible containing the weighed sample of coal is placed in an air oven with the cover off, and allowed to remain one (1) hour, the temperature of the oven being being kept at 105 to 110 deg. C.

The crucible is removed after remaining in the oven an hour, put into a desiccator over concentrated sulphuric acid, allowed to cool for a few minutes and then weighed. Difference in weight between first and second weights equals moisture.

VOLATILE MATTER

After determining the moisture the crucible containing the dry coal is placed on a clay triangle which is so placed that the crucible will be 6 to 8 cm. above top of a Bunsen burner. Adjust the burner so that it gives a flame of about 20 cm. in height. Place burner under crucible in such a way that flames envelop the crucible and heat thus for seven (7) minutes in a place free from draughts. (Carbon should be burned from the outside of the crucible should any collect.) Cool and weigh. Difference between second and third weights equals volatile matter.

FIXED CARBON AND ASH

Heat the crucible containing the remaining material from the determination of volatile matter until coke is red hot at edge. Then pass into the crucible slow stream of oxygen gas from the tank, through a small metal or glass nozzle until all carbonaceous matter is burned. Test by reheating crucible and again passing oxygen into it.

Note.—Oxygen must be used very carefully or mechanical loss will result from small ash particles being thrown from the crucible.

Cool and weigh. Difference between third and last weighing equals fixed carbon. The difference between the weight of the empty crucible and last weight equals ash. For example:—

Crucible + lid empty = 9.7136 (1)
Crucible + lid and coal = 10.7136

Then going through with the different weighings:—

(1) 10.7136	(2) 10.6575	(3) 10.3198	(4) 9.9202
(2) 10.6575	(3) 10.3198	(4) 9.9202	(1) 9.7136
0.0561	0.3377	0.3996	0.2066

Moisture = 5.61 per cent.
Volatile Matter = 33.77 per cent.
Fixed Carbon = 39.96 per cent.
Ash = 20.66 per cent.

NOTE.—Ash determined by the above method is usually lower than the ash as determined by the method recommended in the "Report of the Committee on Coal Analysis" — Journal American Chemical Society, 1899 — p. 1116.

This difference is probably due to the complete removal of CO_2 from the ash by the above method, which in the coal was combined with calcium in the form of $CaCO_3$ or limestone. The method given in the report of the Committee does not completely decompose the $CaCO_3$, hence the difference.

B. T. U. DETERMINATION

Another sample of 0.5 gram is taken from the bottle containing the 100-mesh sample. Should the moisture content of this sample be over 3.5 per cent. as determined by the approximate analysis, the weighed sample is placed on a watch glass and put in the oven where it is kept at 105 deg. C. for about half an hour; by this treatment the moisture will be reduced enough to allow the B. T. U. determination to be made. A Parr Standard Calorimeter is used, manipulation as given in directions furnished with the instrument.

SULPHUR IN COAL

The residue is carefully removed from the bomb of the Parr calorimeter to a clean beaker covered with a watch glass, the bomb is carefully rinsed into the beaker with hot water from a wash bottle. The beaker is then covered with watch glass and 30 c. c. of concentrated c. p. hydrochloric acid slowly added, keeping beaker well covered. After reaction has ceased the solution should be acid, the solution is filtered to remove any foreign particles, filter well washed with hot water until filtrate amounts to about 200 c. c. Heat filtrate to boiling, then keeping just below the boiling point, add very slowly, with constant stirring, through a pipette or other device, 10 c. c. of a 10 per

cent. barium chloride solution. Add solution of barium chloride so slowly that eight to ten minutes are consumed for the addition. After all the barium chloride has been added, heat and stir for five minutes more, then set aside. When barium sulphate has settled well decant liquid through an Ashless filter, wash the precipitate several times with hot water by decantation, transfer to the filter and wash until washings are free from chloride.

Place moist filter in weighed crucible, drive off moisture with a very small flame, char slowly, then increase heat until all carbon is removed. Cool and weigh. Weight of barium sulphate × 2 if 0.5 grams were taken × 0.1373 equals weight of sulphur in 1 gram of coal.

For a more rapid method the Parr sulphur photometer may be used. Directions sent with instrument are followed.

ANALYSIS OF ASH

Samples of ash are treated the same as coal, the ash is sampled and pulverized to pass a 100–mesh sieve.

Moisture, volatile matter, fixed carbon and ash are determined in the same manner as with coal. Care must be used, when working with ash, to burn out all the carbon present, there being so much mineral matter, traces of carbon may be left in the ash residue.

In making the B. T. U. determination on an ash, should the combustible matter be so low that the charge does not ignite, benzoic acid is used along with the ash to help the combustion.

Several blanks are run with benzoic acid alone, using 0.5 gram for a combustion. Then a sample is run with 0.25 gram of benzoic acid and 0.5 gram of ash. Then subtracting the rise due to the added benzoic acid (one-half of the indicated rise for a 0.5 gram) from the total rise due to benzoic acid plus ash, the rise due to ash is obtained from which the heating value is calculated in the usual way.

EXHIBIT II

METHOD USED IN THE LABORATORY OF THE CLEVELAND RAILWAY COMPANY FOR ANALYZING COAL

Paper by L. P. Crecelius, Superintendent of Power

SAMPLING

Each car of coal of each day's consignment is sampled by what is known as the ram method. This consists in driving a steel ram (5 ft. long, 2½ in. internal diameter, with studs projecting here and there on the inside, and one end capped) into various parts (usually eight) of the car, and emptying the small quantities thus obtained (about 50 lb. altogether) into a canvas bag made for this purpose. By taking the coal from the middle, sides, and ends of the car throughout the

various strata in this way, a fair sample of the whole is easily and quickly obtained. The sample from each car is roughly crushed, thoroughly mixed, quartered down to two pounds, and put through a coffee mill.

This coal, now about the size of BB shot, is brought to the laboratory for the final sampling. The two pound samples from each car are thoroughly mixed together with a large spatula in order to obtain a fair average of the whole day's shipment. Slack coal and run-of-mine coal are not mixed, however, but treated as separate samples. The mixed coal is now quartered down until about one pound of the original amount is left. This part is again mixed, spread out in a thin layer, and about one ounce of it removed with a small spatula, from the various points, to be used as the sample for analysis. The remainder is put away in an air-tight sample jar, properly labeled for future reference.

The smaller part is ground repeatedly with a muller and bucking-board until the whole will pass through a 100–mesh sieve. This pulverized, sifted sample is again mixed and put into the oven for one hour at a temperature of 100 deg. C. The oven consists of a copper heater surrounded by a water jacket, in which the water is kept at a boiling temperature by a Bunsen burner. The coal, now dried out, is transferred to a stoppered glass tube and placed in a desiccator (sulphuric acid). When cold, the sample is ready for analysis. Ash, sulphur and British Thermal Units are the constituents usually determined — though moisture, volatile matter and fixed carbon are sometimes required for boiler and stoker tests.

Ash Determination

One gram of the dried coal is accurately weighed up into a clean 20 c. c. platinum crucible for the ash determination. This consists in merely allowing the coal to completely burn out over a full Fletcher burner flame. Sometimes the sample is heated to constant weight, but if burned for three or four hours with frequent and careful stirring, the extra weighing is unnecessary, thus saving time. From the weight of the residue found the percentage of ash in the sample is calculated in the usual way. A half gram of coal may be used instead of a whole gram, though any error is doubled in this way. Two determinations are made at a time on one sample, and should check within 0.2 per cent. which is approximately 2 per cent. error on average coal.

Sulphur Determination

For the sulphur a half gram of the dry sample is weighed up. Two determinations are carried on simultaneously on each sample, in order to have a check on the results. The half gram of coal is put into a 20 gram platinum crucible half filled with Eschka's mixture, then

stirred together, covered with a little more of the mixture, and placed over a Fletcher flame turned very low, for fifteen minutes. Eschka's mixture consists of two parts by weight of calcined magnesium oxide (MgO) and one part by weight of anhydrous sodium carbonate (Na_2CO_3). At the end of fifteen minutes the flame is turned up until the tip just touches the bottom of the crucible, kept there for ten minutes, then turned up to full power. The mixture is heated for three-quarters of an hour over the full flame, being stirred several times with a platinum rod during the last half-hour. After the whole has been fused, and the coal completely burned out, the cooled contents of each crucible is turned into a clean beaker, that part of the fusion adhering to the crucible being washed out by means of distilled water and a rubber tipped stirring rod.

Fifty c.c. of distilled water are added to the beaker, the whole allowed to boil a minute on the hot plate, then filtered through a single filter (Munktell No. O, 9 cm.) and the precipitate washed three times with hot distilled water, 15 c.c. of 1 to 1 hydrochloride acid (HCl, sp. gr. 1.19) added to the filtrate, the solution boiled for a minute and stirred, then 8 c.c. of saturated barium chloride solution ($BaCl_2$) added and the resulting precititate of barium sulphate ($BaSO_4$) allowed to settle, while the beaker rests on the hot plate.

When the precipitate has settled, the supernatant liquid is decanted through double filters (Munktell No. O, 9 cm.) and the filter papers washed carefully three times with hot distilled water. The $BaSO_4$ precipitate is now washed upon the filter and then washed ten times with hot water. To the last washing is added a few drops of 3/10 normal silver nitrate solution ($AgNO_3$). If no white precipitate of silver chloride (AgCl) is formed the $BaSO_4$ is washed only once more, but if the presence of chloride is indicated by this test, the washing is continued until the addition of silver nitrate reagent produces no opalescence.

The filters are now folded around the precipitate, both placed in a clean platinum crucible, and heated over the flame until the paper is completely burned off. This takes about half an hour. From the weight of precipitate found, is subtracted the weight of $BaSO_4$ obtained as the average of two or three blanks previously run on the Eschka's mixture. The corrected weight of sulphate is doubled (as but half a gram of sample was taken), and multiplied by 13.74 (the percentage of sulphur in $BaSO_4$), to obtain the percentage of sulphur in the coal sample. A sulphur table for half gram weights is made up for reference, thus saving time in figuring results. Duplicate determinations should check within 2 per cent. error.

With six burners and six crucibles at hand, six determinations (sulphur or ash) on three samples of coal are carried on at one time. Using the Eschka method, six complete sulphur determinations can be made in about three and one-half hours, exclusive of time allowed

for settling of the $BaSO_4$ precipitate, which takes two hours or longer — although less time is often given for this. It is proposed to try to shorten the time of the sulphur determination by making use of a volumetric instead of a gravimetric method, as above. This may be done by titration of the bomb rinsings (see B. T. U. determination below) using standard solutions of sodium carbonate and barium chloride.

While the samples are being heated in the crucibles for ash and sulphur, the B. T. U. determinations are made.

B. T. U. Determination

This is accomplished with an Atwater bomb calorimeter, which measures the rise in temperature of a definite quantity of distilled water, due to the heat absorbed from combustion of a fixed amount of coal sample in an atmosphere of pure oxygen. This combustion takes place in a steel bomb, which is immersed in a cylinder of water, the latter being kept in circulation by a brass stirrer operated by an electric motor. The cylinder, water, and bomb are protected from outside heat by two fibre tubs and two hard rubber covers, with air spaces between. The coal is ignited by passing a storage battery current through an iron fuse wire (stretched across the platinum terminals inside the bomb, which support the coal capsule) just above the sample. The bomb itself consists of five parts, all steel: the cylindrical shaped threaded cup (of about 380 c.c. capacity) with a platinum lining in the form of a removable inner cup; the bomb cover with platinum lining and terminal wires and valve for the admission of oxygen; the value pin; the cylindrical valve screw; and the threaded collar for tightening the bomb cover.

To determine the heat units in a sample of coal, the bomb is taken apart and the threads, cover gasket (of lead) and all outside surfaces thoroughly greased with vaseline. One gram of dried coal is accurately weighed up into a clean nickel capsule (of about 2 c.c. capacity), placed on the platinum gasket support (one of the cover terminals), and the iron fuse wire fastened into position. The bomb parts are now put together, a spanner wrench being used on the collar to insure a tight joint and the bomb filled with oxygen to 25 atmospheres. The oxygen (approximately 95 per cent. Oxygen and 5 per cent. Nitrogen) is furnished in 100 cu. ft. cylinders of 120 atmospheres pressure by the Linde Air Products Co. of Buffalo, N. Y. With three cylinders on hand, two are connected up in parallel, the bomb being filled first from the partially emptied tank to its pressure and shut off. and then from the high pressure cylinder to 25 atmospheres. In this way all oxygen up to one atmosphere pressure may be used from each tank.

Exactly 1840 grams of distilled water at a temperature 3 deg. C. below room temperature are weighed up, using a sealed glass jar

weighted with BB shot as a tare for the water, metal cylinder and stirring rings. The filled bomb is immersed in the water, the cylinder placed in the inner fibre tub, the battery terminals connected to the bomb cover, the tub lids put on, the stirring apparatus adjusted to a worm-gear motor and put in motion and thermometer inserted through holes in the covers so that the mercury bulb is about half way up from the cylinder bottom. The thermometer is of the Beckmann type, reading differences in temperature from 0 to 6 in C. degrees, graduated in 0.01 and capable of being read with the aid of a microscope, to 0.001 deg. C.

The time of starting the motor is noted, and the water circulated for five minutes, during which time the temperature of the calorimeter system will have become uniform. At the end of five minutes a reading is taken on the thermometer, the latter being tapped with a buzzer previous to all readings to overcome the lag of the mercury in the capillary. Another reading is taken in two minutes, and the switch (connecting the battery and fuse) thrown in at the same time. (A system of relays and a 1 c. p. lamp prevents more current than necessary from passing through the bomb, thus cutting off a possible source of error from electrical heating.) The difference between these two readings divided by two will obviously give the rate of rise per minute; the temperature of the water being lower than that of the room. The combustion of the coal and absorption of heat is complete in five minutes, when another reading is taken. The difference between the latter reading and that just before ignition is the indicated rise due to the burning of the coal sample in question, but several corrections must be applied to this figure in order to obtain the true rise. A final period of two minutes is necessary to determine the loss (or gain) in temperature per minute due to radiation (or absorption). This rate of change per minute is calculated as the initial period. This latter change is always negative if the water used is but 3 deg. C. lower than the room temperature, as the immersion of the bomb increases the water temperature slightly, and the combustion of the coal causes a rise of approximately 3 deg. C. The thermometer readings must first be corrected for irregularities in bore of the capillary and then what is known as the setting factor correction is applied. The latter is dependent upon the amount of mercury being used from the reservoir at the top of the thermometer. As the room is warmer or cooler, less or more mercury, respectively, must be used, necessitating the expenditure of more or less heat, respectively, in causing a rise of one true Centigrade degree. Both of these corrections are obtained directly from tables calculated from figures furnished with the thermometer. The total radiation or absorption (as the case may be) is figured by using a short cut of the Regnault-Pfandler formula. It had been noticed from day to day, in making the B. T. U. test, that approximately the total rise in temperature occurred during the

first two minutes of the combustion period. Consequently, assuming the rise to be fairly uniform during this period, the total temperature change during this time is the average gain or loss per minute (one-half the algebraic sum of the gain per minute during the initial period and the loss (or gain) per minute during the final period) × 2. During the last three minutes of the combustion period the radiation (or absorption) is practically constant, so that the rate of change per minute × 3 gives the total change in temperature. In short, the total radiation or absorption correction for this calorimeter is the algebraic sum of the initial rate of change and four times the final rate of change, with a five minute combustion period.

The accuracy of this short-cut method is confirmed by the fact that the average difference with 60 B. T. U. determinations, using both formulae, was three and one-half gross B. T. U. or one B. T. U. At least ten minutes per determination may be saved in the calculation in this way.

By experiment it has been determined that the water equivalent of this calorimeter is 423. This means that the bomb, cylinder, stirrer, etc., are equivalent to 423 grams of water, on a heat absorption basis. This figure is the average of several obtained by burning a certain weight of benzoic acid (the heat of combustion of which is definitely known), and noting the rise in degrees. A British Thermal Unit is the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit, when the water has a specific heat of one. For practical purposes the change of specific heat of water through various laboratory temperatures is negligible. A rise of one degree with this calorimeter represents 4073 B. T. U., viz., 423 (grams water equivalent) + 1840 (grams water used in cylinder) × 1.8 (Fahr. deg. in 1 deg. C.) = 4073.

Referring to a calorific table (made out for each 0.001 deg. C.) the corresponding B. T. U. for any rise (corrected for bore, setting and absorption or radiation) is directly obtained.

Still further corrections for nitrogen, sulphur and unburned fuse-wire must be applied. The nitrogen in the air in the bomb and the nitrogen in the coal sample is burned to nitric acid in the bomb, producing heat, whereas, in a furnace this nitrogen is not burned. Likewise, the sulphur in the coal is burned to sulphuric acid in the bomb, and to sulphur dioxide in the furnace.

After the final reading the gas is allowed to escape slowly from the bomb, the latter taken apart, the inside surfaces rinsed with cold water, and the rinsings titrated with decinormal sodium carbonate solution. The bomb washings contain both sulphuric and nitric acids and allowance must be made for the former in making the nitric acid correction. This is done as follows: Per cent. sulphur × 6.25 = No. c. c. $N/_{10}$ Na_2CO_3 for sulphuric acid. 1 c.c. decinormal sodium

carbonate solution contains 0.0053 gm. salt which is equivalent to 0.0049 gm. sulphuric acid or 0.0016 gm. sulphur. Therefore if 1 c.c. Na_2CO_3 represents 0.0016 gm. sulphur, 1 per cent. sulphur (using 1 gm. coal sample), or 10 gm., require 6.25 c.c. $N/_{10}$ Na_2CO_3 for sulphuric acid. 1 c.c. decinormal sodium carbonate solution contains 0.0053 gm. salt which is equivalent to 0.0049 gm. sulphuric acid or 0.0016 gm. sulphur. Therefore, if 1 c.c. Na_2CO_3 represents 0.0016 gm. sulphur, 1 per cent. sulphur (using 1 gm. coal sample), or 10 gm., require 6.25 c.c. $N/_{10}$ carbonate solution. Total titration c.c. for sulphuric acid = c.c. for nitric acid. Exces c.c. of $N/_{10}$ Na_2CO_3 × 2.57 = B. T. U. to be subtracted for HNO_3. The specific heat of combustion of nitric acid is 409 B. T. U. per gram. One c.c. of $N/_{10}$ Na_2CO_3 neutralizes 0.0053 gm. nitric acid. Therefore 409 B. T. U. × 0.00063 = 2.57 B. T. U. per c.c. $N/_{10}$ Na_2CO_3

With coal coming from the same territory with about the same nitrogen content, no serious error will be introduced by doing away with the titration and using the average of several nitrogen figures. This correction is a minor one, and several minutes may be saved in this way on each determination.

The difference in specific heat of combustion of sulphuric acid and sulphur dioxide is 3960 B. T. U. per gram of sulphur. Consequently for each per cent. of sulphur in the coal sample, 39.6 B. T. U. is to be subtracted from the figure obtained from the calorific table.

The fuse wire, of pure iron, is 3 7/16 in. long and weighs 22.66 gms. As the specific heat of combustion of iron is 2882 B. T. U. per gram, 65 B. T. U. are produced by the burning of the fuse and must be deducted, this being the final correction in the B. T. U. determination. For each 1/16 in. of unburned wire one less B. T. U. is subtracted. The last three correction figures are obtained directly from tables.

After each determination the bomb is taken apart, washed, dried, and greased for the next determination. A complete B. T. U. test may be made in this manner in thirty minutes. The figures obtained on two determinations on the same sample should agree within 40 B. T. U. The average agreement on duplicate determinations during the first year of use with this calorimeter (not including about twenty figures which did not check within 0.66⅔ per cent. error) was 27 B. T. U. This represents an error of less than 0.25 per cent. on 13,000 B. T. U. coal. With good care more than 1200 determinations may be made on a new calorimeter before any repairs are necessary. These repairs (reseating valve pin corroded by acid, replacing top lining, and wires, etc.) are comparatively inexpensive, and when made from time to time, increase the life of the bomb many fold.

Ash and Coke B. T. U. Determination

The only difference between this and the foregoing determination, is that but a quarter gram sample of dried, pulverized ash or coke is taken. This is thoroughly mixed (with a stiff pin) with one gram of standard coal (the B. T. U. and sulphur content of which are known) and the test carried on just as above. In the calculating, the heat produced by the standard coal (both coal and sulphur) is deducted from the total heat and the remainder multiplied by four (as but ¼ gm. ash or coke was taken) to obtain B. T. U. in sample.

Moisture Determination

To find the moisture content the coal in question is coarsely crushed, then air-dried (or taken as received), depending upon the purpose for which this determination is required, a gram of it weighed up, placed in the heater at 100 deg. C. for one hour and weighed again. The loss in weight × 100 divided by the weight of air dried coal gives the per cent. of moisture.

Volatile Matter Determination

A one gram sample of pulverized coal (not dried, and the moisture content of which is known) is placed in a clean, weighed, platinum crucible, and the cover (included in the weighing) put on tightly. The whole is now so supported that the bottom of the crucible is just 12 cm. above the top of the Fletcher burner, and the coal is heated for just seven minutes over a flame 20 cm. high. The loss in weight of the cooled crucible is the volatile matter and moisture which has been driven out. This loss (minus the moisture previously determined) gives volatile matter on moist coal. The latter figure divided by 100 per cent. moisture gives volatile matter on dry coal.

Fixed Carbon Determination

The cover is removed, and the carbon burned off until nothing remains but the ash — the loss is fixed carbon.

B. T. U. Data

The following tables have been made to facilitate calculations after the actual test is completed.

BORE CORRECTIONS:

The bore correction is simply a calibration which must be added or subtracted according to the algebraic signs.

SETTING FACTOR:

To obtain the setting factor it is necessary to take a reading on the Beckmann thermometer (which has been adjusted for conditions of the test) before or after an explosion, and at the same time take the temperature of the calorimeter by inserting a Centigrade thermometer in the water. The difference between these two readings gives the setting and the factor opposite it is the number by which the corrected degrees rise must be multiplied for the true temperature rise.

B. T. U. TABLE:

A rise of temperature of one degree represents 4073 B. T. U. The table is made up from this figure for each 0.001 deg. of temperature change throughout the range of values required.

SULPHUR TABLE:

The values in this table are obtained by multiplying the corrected weight of Barium sulphate by the per cent. of sulphur (13.74) in the sulphate, for each milligramme difference in weight, throughout the range of values required.

SULPHUR CORRECTION TABLE:

For each per cent. of sulphur in the coal sample, 39.6 B. T. U. must be subtracted from the value obtained from the B. T. U. table, on account of the difference of heat of combustion of sulphur in an ordinary furnace and in oxygen. The table is therefore made up by multiplying each per cent. of sulphur by 39.6 throughout the range of values desired.

UNBURNED FUSE TABLE:

The combustion of the fuse wire which is 3 7/16 in. long, produces 65 B. T. U. This is approximately one B. T. U. for each 1/16 in. of the wire. Therefore for each 1/16 in. of fuse wire unburned, one B. T. U. must be deducted from the heat units allowed for the total length.

THERMOMETER CORRECTIONS

Setting Factor P. T. R. 0.39227

Setting		Factor	Setting		Factor
10 deg. C.....	Equals 1.0030		18 deg. C.....	Equals 1.0062	
11 "	" 1.0034		19 "	" 1.0066	
12 "	" 1.0038		20 "	" 1.0070	
13 "	" 1.0042		21 "	" 1.0074	
14 "	" 1.0046		22 "	" 1.0078	
15 "	" 1.0050		23 "	" 1.0082	
16 "	" 1.0054		24 "	" 1.0086	
17 "	" 1.0058		25 "	" 1.0090	

THERMOMETER CORRECTIONS — (*Continued.*)

Bore	Correction	Bore	Correction	Bore	Correction
0.0 deg.,C	Equals 0.0000	2.0 deg..	Equals 0.0110	4.0 deg.,C	Equals 0.0080
0.1 " ..	" 0.0007	2.1 " ..	" 0.0109	4.1 " ..	" 0.0077
0.2 " ..	" 0.0014	2.2 " ..	" 0.0108	4.2 " ..	" 0.0074
0.3 " ..	" 0.0021	2.3 " ..	" 0.0107	4.3 " ..	" 0.0071
0.4 " ..	" 0.0028	2.4 " ..	" 0.0106	4.4 " ..	" 0.0068
				4.5 " ..	" 0.0065
0.5 " ..	" 0.0035	2.5 " ..	" 0.0105		
0.6 " ..	" 0.0042	2.6 " ..	" 0.0104	4.6 " ..	" 0.0062
0.7 " ..	" 0.0049	2.7 " ..	" 0.0103	4.7 " ..	" 0.0059
0.8 " ..	" 0.0056	2.8 " ..	" 0.0102	4.8 " ..	" 0.0056
0.9 " ..	" 0.0063	2.9 " ..	" 0.0101	4.9 " ..	" 0.0053
1.0 " ..	" 0.0070	3.0 " ..	" 0.0100	5.0 " ..	" 0.0050
1.1 " ..	" 0.0074	3.1 " ..	" 0.0098	5.1 " ..	" 0.0045
1.2 " ..	" 0.0078	3.2 " ..	" 0.0096	5.2 " ..	" 0.0040
1.3 " ..	" 0.0082	3.3 " ..	" 0.0094	5.3 " ..	" 0.0035
1.4 " ..	" 0.0086	3.4 " ..	" 0.0092	5.4 " ..	" 0.0030
1.5 " ..	" 0.0090	3.5 " ..	" 0.0090	5.5 " ..	" 0.0025
1.6 " ..	" 0.0094	3.6 " ..	" 0.0088	5.6 " ..	" 0.0020
1.7 " ..	" 0.0098	3.7 " ..	" 0.0086	5.7 " ..	" 0.0015
1.8 " ..	" 0.0102	3.8 " ..	" 0.0084	5.8 " ..	" 0.0010
1.9 " ..	" 0.0106	3.9 " ..	" 0.0082	5.9 " ..	" 0.0005
				6.0 " ..	" 0.0000

SULPHUR TABLE

Wt. $BaSO_4$	Per cent sulphur	Wt. $BaSO_4$	Per cent sulphur	Wt. $BaSO_4$	Per cent sulphur	Wt. $BaSO_4$	Per cent sulphur	Wt. $BaSO_4$	Per cent sulphur
0.035.....	0.96	0.067..	1.84	0.099..	2.72	0.131..	3.60	0.163..	4.48
0.036.....	0.99	0.068..	1.87	0.100..	2.75	0.132..	3.62	0.164..	4.50
0.037.....	1.02	0.069..	1.89	0.101..	2.77	0.133..	3.65	0.165..	4.53
0.038.....	1.04	0.070..	1.92	0.102..	2.80	0.134..	3.68	0.166..	4.56
0.039.....	1.07	0.071..	1.95	0.103..	2.83	0.135..	3.71	0.167..	4.59
0.040.....	1.10	0.072..	1.98	0.104..	2.86	0.136..	3.73	0.168..	4.61
0.041.....	1.13	0.073..	2.00	0.105..	2.88	0.137..	3.76	0.169..	4.64
0.042.....	1.15	0.074..	2.03	0.106..	2.91	0.138..	3.79	0.170..	4.67
0.043.....	1.18	0.075..	2.06	0.107..	2.94	0.139..	3.82	0.171..	4.70
0.044.....	1.21	0.076..	2.09	0.108..	2.97	0.140..	3.84	0.172..	4.72
0.045.....	1.24	0.077..	2.11	0.109..	2.99	0.141..	3.87	0.173..	4.75
0.046.....	1.26	0.078..	2.14	0.110..	3.02	0.142..	3.90	0.174..	4 78
0.047.....	1.29	0.079..	2.17	0.111..	3.05	0.143..	3.93	0.175..	4.81
0.048.....	1.32	0.080..	2.20	0.112..	3.08	0.144..	3.95	0.176..	4.83
0.049.....	1.35	0.081..	2.22	0.113..	3.10	0.145..	3.98	0.177..	4.86
0.050.....	1.37	0.082..	2.25	0.114..	3.13	0.146..	4.01	0.178..	4.89
0.051.....	1.40	0.083..	2.28	0.115..	3.16	0.147..	4.04	0.179..	4.92
0.052.....	1.43	0.084..	2.31	0.116..	3.19	0.148..	4.06	0.180..	4.94
0.053.....	1.46	0.085..	2.33	0.117..	3.21	0.149..	4.09	0.181..	4.97
0.054.....	1.48	0.086..	2.36	0.118..	3.24	0.150..	4.12	0.182..	5.00
0.055.....	1.51	0.087..	2.39	0.119..	3.27	0.151..	4.15	0.183..	5.03
0.056.....	1.54	0.088..	2.42	0.120..	3.30	0.152..	4.17	0.184..	5.05
0.057.....	1.57	0.089..	2.44	0.121..	3.32	0.153..	4.20	0.185..	5.08
0.058.....	1.59	0.090..	2.47	0.122..	3.35	0.154..	4.23	0.186..	5.11
0.059.....	1.62	0.091..	2.50	0.123..	3.38	0.155..	4.26	0.187..	5.14
0.060.....	1.65	0.092..	2.53	0.124..	3.41	0.156..	4.28	0.188..	5.16
0.061.....	1.68	0.093..	2.55	0.125..	3.43	0.157..	4.31	0.189..	5.19
0.062.....	1.70	0.094..	2.58	0.126..	3.46	0.158..	4.34	0.190..	5.22
0.063.....	1.73	0.095..	2.61	0.127..	3.49	0.159..	4.37	0.191..	5.24
0.064.....	1.76	0.096..	2.64	0.128..	3.51	0.160..	4.39	0.192..	5.27
0.065.....	1.78	0.097..	2.66	0.129..	3.54	0.161..	4.42	0.193..	5.30
0.066.....	1.81	0.098..	2.69	0.130..	3.57	0.162..	4.45	0.194..	5.33

Atwater Sulphur Correction Table

Per cent sulphur	B. T. U.	Per cent sulphur	B. T. U.	Per cent sulphur	B. T. U.	Per cent sulphur	B. T. U.
0.90.....	36	1.95.....	77	3.00.....	119	4.05.....	160
0.95.....	38	2.00.....	79	3.05.....	121	4.10.....	162
1.00.....	40	2.05.....	81	3.10.....	123	4.15.....	164
1.05.....	42	2.10.....	83	3.15.....	125	4.20.....	166
1.10.....	44	2.15.....	85	3.20.....	127	4.25.....	168
1.15.....	46	2.20.....	87	3.25.....	129	4.30.....	170
1.20.....	48	2.25.....	89	3.30.....	131	4.35.....	172
1.25.....	49	2.30.....	91	3.35.....	133	4.40.....	174
1.30.....	51	2.35.....	93	3.40.....	135	4.45.....	176
1.35.....	53	2.40.....	95	3.45.....	137	4.50.....	178
1.40.....	55	2.45.....	97	3.50.....	139	4.55.....	180
1.45.....	57	2.50.....	99	3.55.....	141	4.60.....	182
1.50.....	59	2.55.....	101	3.60.....	143	4.65.....	184
1.55.....	61	2.60.....	103	3.65.....	145	4.70.....	186
1.60.....	63	2.65.....	105	3.70.....	147	4.75.....	188
1.65.....	65	2.70.....	107	3.75.....	148	4.80.....	190
1.70.....	67	2.75.....	109	3.80.....	150	4.85.....	192
1.75.....	69	2.80.....	111	3.85.....	152	4.90.....	194
1.80.....	71	2.85.....	113	3.90.....	154	4.95.....	196
1.85.....	73	2.90.....	115	3.95.....	156	5.00.....	198
1.90.....	75	2.95.....	117	4.00.....	158	5.05.....	200

Unburned Fuse Table

In. wire	B. T. U.	In. wire	B. T. U.	In. wire	B. T. U.	In. wire	B. T. U.	In wire.	B. T. U.
0.....	65	5/16...	59	5/8..	53	15/16.	47	1 1/4.	42
1/16....	64	3/8....	58	11/16.	52	1.....	46	1 5/16	40
1/8.....	63	7/16...	57	3/4..	51	1 1/16	45	1 3/8.	39
3/16....	62	1/2....	56	13/16.	50	1 1/8.	44	1 7/16	38
1/4.....	61	9/16...	55	7/8..	49	1 3/16	43	1 1/2.	37

Atwater Calorific Table

Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.
2.905	11,832	2.920	11,893	2.935	11,954	2.950	12,015	2.965	12,076
2.906	11,836	2.921	11,897	2.936	11,958	2.951	12,019	2.966	12,081
2.907	11,840	2.922	11,901	2.937	11,962	2.952	12,023	2.967	12,085
2.908	11,844	2.923	11,905	2.938	11,966	2.953	12,028	2.968	12,089
2.909	11,848	2.924	11,909	2.939	11,971	2.954	12,032	2.969	12,093
2.910	11,852	2.925	11,914	2.940	11,975	2.955	12,036	2.970	12,097
2.911	11,857	2.926	11,918	2.941	11,979	2.956	12,040	2.971	12,101
2.912	11,861	2.927	11,922	2.942	11,983	2.957	12,044	2.972	12,105
2.913	11,865	2.928	11,929	2.943	11,987	2.958	12,048	2.973	12,109
2.914	11,869	2.929	11,930	2.944	11,991	2.959	12,052	2.974	12,113
2.915	11,873	2.930	11,934	2.945	11,995	2.960	12,056	2.975	12,117
2.916	11,877	2.931	11,938	2.946	11,999	2.961	12,060	2.976	12,121
2.917	11,881	2.932	11,942	2.947	12,003	2.962	12,064	2.977	12,125
2.918	11,885	2.933	11,946	2.948	12,007	2.963	12,068	2.978	12,129
2.919	11,889	2.934	11,950	2.949	12,011	2.964	12,072	2.979	12,133

ATWATER CALORIFIC TABLE — (*Continued*)

Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.
2.980	12,138	3.040	12,382	3.100	12,626	3.160	12,871	3.220	13,115
2.981	12,142	3.041	12,386	3.101	12,630	3.161	12,875	3.221	13,119
2.982	12,146	3.042	12,390	3.102	12,634	3.162	12,879	3.222	13,123
2.983	12,150	3.043	12,394	3.103	12,639	3.163	12,883	3.223	13,127
2.984	12,154	3.044	12,398	3.104	12,643	3.164	12,887	3.224	13,131
2.985	12,158	3.045	12,402	3.105	12,647	3.165	12,891	3.225	13,135
2.986	12,162	3.046	12,406	3.106	12,651	3.166	12,895	3.226	13,139
2.987	12,166	3.047	12,410	3.107	12,655	3.167	12,899	3.227	13,144
2.988	12,170	3.048	12,415	3.108	12,659	3.168	12,903	3.228	13,148
2.989	12,174	3.049	12,419	3.109	12,663	3.169	12,907	3.229	13,152
2.990	12,178	3.050	12,423	3.110	12,667	3.170	12,911	3.230	13,156
2.991	12,182	3.051	12,427	3.111	12,671	3.171	12,915	3.231	13,160
2.992	12,186	3.052	12.431	3.112	12,675	1.172	12,920	3.232	13,164
2.993	12,190	3.053	12,435	3.113	12,679	3.173	12,924	3.233	13,168
2.994	12,195	3.054	12,439	3.114	12,683	3.174	12,928	3.234	13,172
2.995	12,199	3.055	12,443	3.115	12,687	3.175	12,932	3.235	13,176
2.996	12,203	3.056	12,447	3.116	12,691	3.176	12,936	3.236	13,180
2.997	12,207	3.057	12,451	3.117	12,696	3.177	12,940	3.237	13,184
2.998	12,211	3.058	12,455	3.118	12,700	1.178	12,944	3.238	13,188
2.999	12,215	3.059	12,459	3.119	12,704	3.179	12,948	3.239	13,192
3.000	12,219	3.060	12,463	3.120	12,708	3.180	12,952	3.240	13,197
3.001	12,223	3.061	12,467	3.121	12,712	3.181	12,956	3.241	13,201
3.002	12,227	3.062	12,472	3.122	12,716	3.182	12,960	3.242	13,205
3.003	12,231	3.063	12,476	3.123	12,720	3.183	12,964	3.243	13,209
3.004	12,235	3.064	12,480	3.124	12,724	3.184	12,968	3.244	13,213
3.005	12,239	3.065	12,484	3.125	12,728	3.185	12,973	3.245	13,217
3.006	12,243	3.066	12,488	3.126	12,732	3.186	12,977	3.246	13,221
3.007	12,248	3.067	12,492	3.127	12,736	3.187	12,981	3.247	13,225
3.008	12,252	3.068	12,496	3.128	12,740	3.188	12,985	3.248	13,229
3.009	12,256	3.069	12,500	3.129	12,744	3.189	12,989	3.249	13,233
3.010	12,260	3.070	12,504	3.130	12,748	3.190	12,993	3.250	13,237
3.011	12,264	3.071	12,508	3.131	12,753	3.191	12,997	3.251	13,241
3.012	12,268	3.072	12,512	3.132	12,757	3.192	13,001	3.252	13,245
3.013	12,272	3.073	12,516	3.133	12,761	3.193	13,005	3.253	13,249
3.014	12,276	3.074	12,520	3.134	12,765	3.194	13,009	3.254	13,254
3.015	12,280	3.075	12,524	3.135	12,769	3.195	13,013	3.255	13,258
3.016	12,284	3.076	12,529	3.136	12,773	3.196	13,017	3.256	13,262
3.017	12,288	3.077	12,533	3.137	12,777	3.197	13,021	3.257	13,266
3.018	12,292	3.078	12,537	3.138	12,781	3.198	13,025	3.258	13,270
3.019	12,296	3.079	12,541	3.139	12,785	3.199	13,030	3.259	13,274
3.020	12,300	3.080	12,545	3.140	12,789	3.200	13,034	3.260	13,278
3.021	12,305	3.081	12,549	3.141	12,793	3.201	13,038	3.261	13,282
3.022	12,309	3.082	12,553	3.142	12,797	3.202	13,042	3.262	13,286
3.023	12,313	3.083	12,557	3.143	12,801	3.203	13,046	3.263	13,290
3.024	12,317	3.084	12,561	3.144	12,806	3.204	13,050	3.264	13,294
3.025	12,321	3.085	12,565	3.145	12,810	3.205	13,054	3.265	13,298
3.026	12,325	3.086	12,569	3.146	12,814	3.206	13,058	3.266	13,302
3.027	12,329	3.087	12,573	3.147	12,818	3.207	13,062	3.267	13,306
3.028	12,333	3.088	12,577	3.148	12,822	3.208	13,066	3.268	13,311
3.029	12,337	3.089	12,581	3.149	12,826	3.209	13,070	3.269	13,315
3.030	12,341	3.090	12,586	3.150	12,830	3.210	13,074	3.270	13,319
3.031	12,345	3.091	12,590	3.151	12,834	3.211	13,078	3.271	13,323
3.032	12,349	3.092	12,594	3.152	12,838	3.212	13,082	3.272	13,327
3.033	12,353	3.093	12,598	3.153	12,842	3.213	13,087	3.273	13,331
3.034	12,357	3.094	12,602	3.154	12,846	3.214	13,091	3.274	13,335
3.035	12,362	3.095	12,606	3.155	12,850	3.215	13,095	3.275	13,339
3.036	12,366	3.096	12,610	3.156	12,854	3.216	13,099	3.276	13,343
3.037	12,370	3.097	12,614	3.157	12,858	3.217	13,103	3.277	13,347
3.038	12,374	3.098	12,618	3.158	12,863	3.218	13,107	3.278	13,351
3.039	12,378	3.099	12,622	3.159	12,867	3.219	13,111	3.279	13,355

ATWATER CALORIFIC TABLE — (*Concluded*)

Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.	Deg. C.	B. T. U.
3.280	13,359	3.305	13,461	3.330	13,563	3.355	13,665	3.380	13,767
3.281	13,364	3.306	13,465	3.331	13,567	3.356	13,669	3.381	13,771
3.282	13,368	3.307	13,469	3.332	13,571	3.357	13,673	3.382	13,775
3.283	13,372	3.308	13,473	3.333	13,575	3.358	13,677	3.383	13,779
3.284	13,376	3.309	13,478	3.334	13,579	3.359	13,681	3.384	13,783
3.285	13,380	3.310	13,482	3.335	13,583	3.360	13,685	3.385	13,787
3.286	13,384	3.311	13,486	3.336	13,588	3.361	13,689	3.386	13,791
3.287	13,388	3.312	13,490	3.337	13,592	3.362	13,693	3.387	13,795
3.288	13,392	3.313	13,494	3.338	13,596	3.363	13,697	3.388	13,799
3.289	13,396	3.314	13,498	3.339	13,600	3.364	13,702	3.389	13,803
3.290	13,400	3.315	13,502	3.340	13,604	3.365	13,706	3.390	13,807
3.291	13,404	3.316	13,506	3.341	13,608	3.366	13,710	3.391	13,812
3.292	13,408	3.317	13,510	3.342	13,612	3.367	13,714	3.392	13,816
3.293	13,412	3.318	13,514	3.343	13,616	3.368	13,718	3.393	13,820
3.294	13,416	3.319	13,518	3.344	13,620	3.369	13,722	3.394	13,824
3.295	13,421	3.320	13,522	3.345	13,624	3.370	13,726	3.395	13,828
3.296	13,425	3.321	13,526	3.346	13,628	3.371	13,730	3.396	13,832
3.297	13,429	3.322	13,531	3.347	13,632	3.372	13,734		
3.298	13,433	3.323	13,535	3.348	13,636	3.373	13,738		
3.299	13,437	3.324	13,539	3.349	13,640	3.374	13,742		
3.300	13,441	3.325	13,543	3.350	13,645	3.375	13,746		
3.301	13,445	3.326	13,547	3.351	13,649	3.376	13,750		
3.302	13,449	3.327	13,551	3.352	13,653	3.377	13,755		
3.303	13,453	3.328	13,555	3.353	13,657	3.378	13,759		
3.304	13,457	3.329	13,559	3.354	13,661	3.379	13,763		

EXHIBIT III

METHOD FOR ANALYZING COAL AS FOLLOWED BY THE DETROIT UNITED RAILWAY

Paper by E. J. Burdick, Superintendent of Power

A sample of coal consisting of about 3 kilograms, in a covered pail, is delivered to the laboratory between 9 and 9:45 each morning. The entire contents of the pail is put through the (Case) crusher which turns it out at one-quarter inch and finer. Then it is quartered down to about one-half kilogram, this is put through the coffee mill. It is then divided into three parts, two of 50 grams each and the other is put in a pint fruit jar, to be kept fifteen days.

The one part of 50 grams is put in the oven for about thirty minutes, and then it is put through the pulverizer, from which the coal comes at 100 mesh. (If it is not dried to a certain extent it sticks, in the pulverizer.)

The other 50 grams is used to determine the moisture.

A representative portion of this pulverized coal is put on watch glasses in the oven for one hour at 105 deg. C., after which it is weighed for the determinations.

For the calorific value of the coal, which is determined with the Atwater Bomb Calorimeter, one gram is used.

For the ash analyses one gram of coal is weighed up and put in a platinum crucible, exposed to the flame from two to three hours, depending on the nature of the coal to pellet, it being stirred several times to insure its being burnt completely. (At present we are using both Bunsen and Meker burners for this work.) The residue is weighed and the weight multiplied by 100 gives the per cent. of ash.

The volatile matter is determined in special coals and ashes. For its determination one gram of coal is put in a platinum crucible with a cover, of a known weight. It is then exposed to a Bunsen flame 8 in. high with the bottom of the crucible 5 in. above the burner. Allow to cool and weigh crucible and contents, subtract this from the original weight of crucible and contents, and multiply the difference by 100, which result is the per cent. volatile matter plus one-half the sulphur.

For determining the sulphur Eschka's method is used. The fusion and precipitation is done in the afternoon and allowed to stand until morning. It is then filtered, washed, ignited and the residue weighed as barium sulphate. The weight of barium sulphate multiplied by 0.13763 (which is the factor for sulphur in barium sulphate) gives the per cent. of sulphur.

EXHIBIT IV

METHOD USED IN THE LABORATORY OF THE PUBLIC SERVICE ELECTRIC COMPANY FOR ANALYZING COAL

Paper by H. A. Benedict, Mechanical Engineer

Superficial Moisture

Superficial moisture is determined by air drying the sample for 24 hours before being ground and noting the loss in weight from which the percentage is computed.

Sample

Sample is ground until it all passes through a 100-mesh sieve. After being thoroughly mixed a portion (15 or 20 grams) is taken as the sample for test and placed in an air tight bottle, the remainder being discarded.

B. T. U. Determination

The calorimeter, which is an Emerson Bomb, is charged with from 0.8 to 1.2 grams of the coal sample, the former being taken of bituminous coals and the latter amount of anthracite, it having been found advisable to use slightly more of the anthracite than of the bituminous, but in no case should the amount exceed 1.2 grams. After the platinum fuse wire (No. 36 B. & S.) has been connected so as to ignite the coal, the bomb is closed and charged with oxygen up to 250 lb. pressure for 0.8 grams of coal or 300 lb. pressure for 1.2 grams of coal.

The bomb is immersed in the calorimeter can which contains 1900 c.c. of distilled water. The room temperature should be equal to or slightly in excess of the temperature of the jacket, and the temperature of the water in the calorimeter can should be from 1.5 to 2.0 deg. C. below the temperature of the jacket. Electrical connections for firing the charge should be made, the thermometer put in place, and the stirrer started. The room temperature, can (water) temperature, and jacket temperature each noted and recorded.

Readings are taken every 30 seconds on the Beckmann thermometer placed in the calorimeter can to determine constant conditions. These readings constitute the first period. The charge is then fired and after 3 minutes have elapsed, readings are again taken on the Beckmann at 30 second intervals until the highest temperature is attained. This constitutes the second period. Readings are continued at 30 second intervals for 5 minutes after the highest temperature is reached, or if the first period was of greater or less duration than 5 minutes the third period must be of exactly the same duration.

All readings on the Beckmann thermometer are corrected in accordance with the certification of the National Bureau of Standards.

Correction

FUSE WIRE:

Platinum fuse wire (No. 36 B. & S.) is used for which there is no correction.

SETTING:

The Beckmann thermometer only indicates the difference in temperature, therefore it becomes necessary in each case to determine the setting, which is obtained by adding the average of the initial and final readings of the first period to the actual temperature. For convenience the temperature of the jacket is used as the actual temperature.

CHANGE 1ST PERIOD:

The initial reading of this period is subtracted from the final reading and the resultant divided by the elapsed time in minutes.

CHANGE 3RD PERIOD:

The final reading of the second period is subtracted from the final reading of the third period and the resultant divided by the elapsed time in minutes.

RADIATION CORRECTION:

The algebraic sum of the changes of the first and third periods divided by twice the elapsed time in minutes of the second period.

STEM CORRECTION.

$Kd\ [(S+n)+T_1+T_2—t]$

when $K=0.00015$

S=Setting

n=2.8 deg. S

T_1=Initian reading of first period.

T_2=Final reading of third period.

$d^2=T_2—T_1$

t=Temperature of emergent stem (omitted as too small to make an appreciable error).

It is customary to set the Beckmann thermometer so that the reading at the surface of the water is 2.8 deg. C., hence $n=2.8$ deg. S.

SETTING CORRECTION:

The difference between the initial and the final readings of the second period is multiplied by the Setting Factor obtained from a table furnished with the Beckmann thermometer. If the Setting Factor is less than unity the correction takes the negative sign and if greater than unity the positive.

NITRIC ACID:

The gaseous products of combustion which are found present in the bomb after the charge is fired are washed in the regular way through a receiving tube terminating under water in a flask and connected to the bomb. After the pressure in the bomb equals the atmospheric pressure, the bomb is opened and rinsed with approximately 250 c.c. of distilled water.

The washings are filtered and titrated with sodium carbonate (Na_2CO_3) for the nitric acid formed during the combustion of the coal. This is done with a standard solution of 3.076 grams of sodium carbonate per liter of distilled water and using methyl-orange as an indicator.

Each c.c. of the standard alkaline solution used is equal to one calorie or its subtractive.

SULPHUR CORRECTION:

The sulphur determination (as explained hereafter) divided by the weight in grams of the charge of coal fired, multiplied by 100 is equal to the sulphur correction in calories and is subtractive.

CORRECTED RISE:

Resultant of the application of corrections to the actual rise in temperature as previously determined.

CALORIES:

The corrected rise in temperature is multiplied by the c.c. of water in the calorimeter can and the water equivalent of the apparatus.

CORRECTED CALORIES:

Calories minus sulphur and nitric acid corrections which are in calories.

B. T. U'S. AIR DRIED:

Corrected calories multiplied by 1.8.

Usually two tests are made in the calorimeter for a check on the B. T. U. figures, the sulphur test following the nitric acid test in each case.

Sulphur Determination

The gaseous products of combustion in the bomb of the calorimeter are washed similarly as in the nitric acid determination. Washings thoroughly filtered, 20 c.c. of hydrochloric acid added, and boiled until clear. While boiling continues, 10 c.c. of a 10 per cent. solution of barium chloride is added drop by drop. The boiling is continued until a white precipitate is formed when the flask is set aside for 12 hours to allow the precipitate to settle. Solution is then heated and filtered into ashless filter paper, the filtrate being tested with barium chloride to determine if sufficient has been added. Filter washed thoroughly and tested for chlorides by adding nitric acid and silver nitrate to the filtrate. Filter is then dried in a weighed platinum crucible in an oven and the filtrate discarded. After drying, the filter is burned to constant weight and weight of barium sulphate determined by subtracting the weight of the crucible from the final weight.

Weight of barium sulphate multiplied by 0.1373 gives per cent. of sulphur in coal.

Inherent Moisture

One gram of sample is weighed out in a platinum crucible and dried for one hour in an oven at 219 to 225 deg. Fahr. Cover placed on crucible and allowed to cool desiccator. Weighed. Loss in weight thus found is the inherent moisture. Operation repeated for check.

Ash or Residue.

The platinum crucible containing the oven dried coal (see Inherent Moisture) is placed over a Bunsen burner and the coal reduced to ash. Burning is continued for one hour, then crucible is cooled in desiccator and weighed. Repeated for another hour in order to insure complete combustion and check former weights.

Weight of residue gives ash per cent.

Volatile Matter

One gram of coal is weighed out in a platinum crucible weighing 20 or 39 grams and having a close fitting cover. The covered crucible is placed over a Bunsen burner in a place shielded from draughts. The flame should be fully 20 cm. high when burning freely and the bottom of the crucible 6 to 8 cm. above the top of the burner. Allow the crucible to remain in the flame just 7 minutes. It is then removed and without removing the cover allowed to cool in the desiccator, and weighed.

The loss in weight gives the volatile matter plus moisture from which the volatile matter is determined.

Carbon

Having determined the moisture (inherent), ash and volatile matter, the carbon is represented by the amount necessary to bring the total up to 100 per cent.

EXHIBIT V

METHODS USED IN THE LABORATORY OF THE WASHINGTON POWER CO., SPOKANE, WASH., FOR ANALYZING COAL

Paper by John B. Fisken, Superintendent Light and Power.

We follow the standard methods only insofar as we can with the apparatus which we feel it advisable to have in our laboratory.

B. T. U. Determination

For the determination of the B. T. U. value, we use the Parr Calorimeter with a curve computed to give a correction for values of radiation and absorption of heat by calorimeter; also use a correction for chemicals of combustion, fuse wire, etc. Thermometer read to nearest 0.01 deg. Fahr.

Ash Determination

For the determination of ash we use a gasoline blow torch in connection with an oxidizing furnace of our own make, using a hard clay crucible and 2000 mgs. of dry coal ground to pass through a 100-mesh screen.

Determination of Volatile Matter

For the determination of volatile matter we use a hard clay crucible, covered tightly and containing 5000 mgs. of dry pulverized coal (not 100-mesh). This crucible and coal is placed in an enclosed furnace and subjected to a gradually increasing heat, produced by a gasoline blow torch, until at the end of 7 minutes the crucible and furnace

are a dull cherry red, and then kept at this heat for 8 minutes longer. The entire operation taking 15 minutes.

Moisture Determination

The drying process is carried on for one hour at 105 deg. C. in watch glasses after the coal has been reduced to pass through a 100-mesh screen.

Note.— The sample ground for the volatile test is not ground as finely as the other samples for the following reason: Western coals (containing as they do so large a percentage of gaseous materials) produce gas so rapidly when slightly heated that there is a great tendency for the finer particles of coal to be carried away with the gas.

EXHIBIT VI

METHODS FOLLOWED IN THE LABORATORY OF THE UNITED RAILWAYS COMPANY OF ST. LOUIS FOR ANALYZING WATER

Material Required for Water Analysis

Analytical balance . .	$65 00
Weights . . .	15 00
50 c.c. pinch clamp burette	1 00
50 c.c. glass stop cock burette	1 50
2–3 in. Royal Berlin porcelain dishes	35
2–6 in. Royal Berlin Porcelain dishes (shallow form)	1 50
6–300 c.c. beakers	1 25
6–3½ in. watch glasses for above beakers	35
1–8 in. copper water bath	2 00
1–6 in. desiccator (porcelain plate)	4 00
Drying oven . .	7 50
4–3 in. funnels . .	1 25
1–10 gram platinum crucible	15 00
6–No. 000 Royal Berlin Porcelain crucibles with covers	80
2–1 liter volumetric flasks	1 10
2–250 c.c. " "	60
2–125 c.c. " "	60
2–100 c.c. " "	45
1–500 c.c. " "	45
2–100 c.c. volumetric pipettes	90
1–50 c.c. " "	30
2–25 c.c. " "	45
2–10 c.c. " "	30
1–5 c.c. " "	10
2–250 c.c. casseroles	75
2–100 c.c. graduated cylinders	90
100– 7 cm. S & S No. 589 filters	65

CHEMICALS

10-grams phenolpthalein, 10-grams methyl-orange, 25-grams potassium chromate, 2-liters c. p. ammonia, 2-liters sulphuric acid (c. p.), 2-liters c. p. hydrochloric acid, ½ lb. c. p. hydrofluric acid, 1-lb. c. p. ammonium chloride, 1-lb. c. p. ammonium oxalate, 1-lb. c. p. sodium ammonium, hydrogen phosphate, 100-grams c. p. silver nitrate, 25-grams c. p. sodium chloride	$5 00

MISCELLANEOUS

2-Bunsen burners, 2 ring stands, 5-500 c.c. Florence flasks, rubber stoppers, reagent bottles, thermometers, glass tubing, etc.	25 00
Total	$154 05

METHOD FOR TESTING BOILER WATER AS FOLLOWED BY THE UNITED RAILWAYS COMPANY OF ST. LOUIS

HARDNESS:

French — Milligrams of $CaCO_3$ in 100 grams, or parts per 100,000 of water; 1 deg. hardness, therefore, equals 0.001 grams of $CaCO_3$ in 100 c.c. of sample.

TEMPORARY HARDNESS:

100 c.c. of the water to be examined are titrated in a porcelain dish with $^{N}/_{10}$ HCl using methyl-orange as an indicator.

Make a blank determination under the same conditions using distilled water. From the amount of $^{N}/_{10}$HCl required for the water subtract that required for the blank.

1 c.c. of $^{N}/_{10}$HCl=0.005 grams $CaCO_3$ or 5 deg. of temporary hardness, using 100 of sample.

PERMANENT HARDNESS, OR NON-CARBONATE HARDNESS:

Place 200 c.c. of the water to be examined in a 300 c.c. Jena Erlenmeyer flask, boil to expel CO_2, then add 50 c.c. $^{N}/_{10}$ soda solution, equal parts of $^{N}/_{10}Na_2CO_3$, $^{N}/_{10}$NaOH. Boil for about 20 minutes, cool and make up to 200 c.c. with distilled water in a volumetric flask, allow to settle pipette or siphon off 100 c c. and titrate with methyl-orange and $^{N}/_{10}$HCl.

Water titrated=100 c.c. of sample and therefore, 25 c.c. $^{N}/_{10}$ alkali, c.c. of acid used subtracted from 25 c.c. = alkali neutralized by acids of permanent hardness × 5 will give the permanent hardness in mgms. per 100,000 or degrees of hardness.

Instead of calculating from the alkali added, a more accurate method would be to run a blank, using distilled water and 50 c.c. of soda mixture, titrating the alkali in 100 c.c. of the blank, the difference between the number of c.c. of $^{N}/_{10}$HCl used for the blank and the number used for the water $\times$ 5 = permanent hardness.

TOTAL MAGNESIUM:

Carefully neutralize 100 c.c. of the water with $^{N}/_{10}$HCl using methyl-orange (portion used for the determination of temporary hardness may be used); heat to boiling to expel the CO_2.

25 c.c. to 50 c.c. of clear lime water, an excess of at least 50 per cent. is placed in a 200 c.c. volumetric flask, add the hot neutralized solution, rinsing with boiling distilled water free from CO_2, make up to 5 c.c. above the mark to allow for contracture. Stopper the flask, shake well and let stand on the water bath for about half an hour. Pipette off 100 c.c. of the clear, cool solution and titrate with $^{N}/_{10}$HCl, using phenolthalein or methyl-orange. Make a blank using distilled water and same amount of lime water (25 or 50 c.c.).

Deducting the amount of $^{N}/_{10}$ acid required for the water from that used for the distilled water $\times$ 5 = hardness due to Mg. in mgms. of $CaCO_3$ per 100,000. Actual Mg. may be obtained by multiplying by 0.24.

Fe if present will be reckoned as Mg. (See Sutton, 1911, p. 483.)

METHOD OF TESTING WATER FOR MINERAL ANALYSIS AS FOLLOWED BY THE UNITED RAILWAYS COMPANY OF ST. LOUIS

Determination of Alkalinity or Acidity

Alkalinity is calculated as $CaCo_3$.

Acidity is calculated as H_2So_4.

ALKALINITY:

Titrate 100 c.c. of the water with $^{N}/_{10}$HCl, using 2 or 3 drops of methyl-orange as an indicator.

ACIDITY DUE TO MINERAL ACIDS:

Titrate 100 c.c .of the sample, in the cold, with $^{N}/_{10}$ Na_2CO_3, using methyl-orange as an indicator. Calculate to free sulphuric acid.

Methyl-orange; dissolve 1 gram of methyl-orange in 1 liter of water and filter.

Analysis

TOTAL SOLIDS:

Evaporate 250 c.c. of the water in a tarred 5 in. porcelain dish; heat for 30 minutes at 105–110 deg. C., cool and weigh. (See Note "a.")

ORGANIC AND VOLATILE MATTER:

Heat dish containing total solids to a dull red until all carbonaceous matter is consumed, cool and weigh. (See Note "b.")

SILICA:

Evaporate 500 c.c. of the water with 3 to 5 c.c. concentrated HCl to dryness, in 6 in. shallow porcelain dish on a water bath; heat in air bath at 180 deg. for 1 hour to dry residue. Add 5–10 c.c. concentrated HCl, 30–40 c.c. distilled water, digest for a few minutes in the water bath, filter, wash with hot water, dry, ignite and weigh as SiO_2. (See Note "c.")

ITON AND ALUMINIUM OXIDES:

To the filtrate from the silica determination add a little bromine water. Boil for a few minutes, add 10–15 c.c. saturated ammonium chloride solution, then a slight excess of ammonium hydroxide, boil for a few minutes, allow to settle, filter, wash with hot water; dry, ignite, and weigh.

CALCIUM, MAGNESIUM AND SULPHUR:

Preliminary:

The filtrate from the above, which should not exceed 225 c.c., made up to 250 c.c. in a volumetric flask with distilled water, shake well, divide solution into two equal parts of 125 c.c. each.

Calcium:

Heat to boiling point one 125 c.c. portion, which should be alkaline with ammonium hydroxide, add 15–25 c.c. of a saturated solution of ammonium oxalate solution. Digest for about 3 hours until solution is clear and precipitate has settled; filter, wash with hot water, dry, ignite and weigh as calcium oxide. Calcium may be titrated with a standard permanganate solution.

If the alkalies are not called for, proceed as follows under *Magnesium*. If they are called for, proceed as given under SODIUM and POTASSIUM.

Magnesium:

Concentrate the filtrate from calcium, to about 200 c.c., add 1/10 of the solution's volume of strong ammonia and then 15–25 c.c. of a saturated solution of ammonium phosphate. Stir well for some minutes, set aside until supernated liquid is clear, filter, wash with 2½ per cent. ammonia water, dry, ignite and weigh as MgP_2O_7

Sulphur:

Slightly acidify the other 125 c.c. portion as obtained by preliminary operation under *Calcium, Magnesium* and *Sulphur,* with hydrochloric acid; heat this to boiling and add, drop by drop, an excess (10–15 c.c.) of a ten per cent. barium chloride solution. Digest for some time on the hot plate, set aside until the solution is clear above the precipitate; filter, wash with hot water, dry, ignite and weigh as $BaSO_4$.

SODIUM AND POTASSIUM:

Instead of using the filtrate from the sulphate for a determination, a better method for most work is that given below.

Transfer the filtrate from the *Calcium* determination to a weighed porcelain dish. Acidify with sulphuric acid, evaporate to dryness, heat to dull redness, cool and add a little ammonia, or ammonium carbonate (if residue is in a crucible), to decompose the acid salts. Drive off ammonium salts by ignition, cool and weigh as $MgSO_4$–Na_2SO_4 and (K_2SO_4). After weighing, dissolve residue in water and determine magnesium as usual. Calculate the magnesium found to $MgSO_4$, subtract from weight of mixed sulphates. The difference equals Na_2SO_4 and (K_2SO_4). In most cases any K_2SO_4 found as above is reported as sodium.

CHLORINE:

Titrate 50 c.c. of the water with a standard solution of silver nitrate, using 1 c.c. of a 5 per cent. solution of potassium chromate as an indicator. Make a blank test using distilled water. If Cl content is small concentrate 250 c.c. of water to 50 c.c.

STANDARD SILVER NITRATE SOLUTION:

Dissolve 5 grams silver nitrate in one liter of chlorine, standardize against a salt solution containing 1.648 grams of NaCl per liter = 0.001 gram Cl per c.c.

CARBONATE AND BICARBONATE RADICLES:

To a 50 c.c. sample of water add a few drops of phenophthalein. Introduce the tip of the burette into the liquid, titrate with $N/_{10}HCl$ until colorless. Let c.c. used = t.

Add two drops of methyl-orange and continue the titration (it is not necessary to have the tip of burette below the surface of the solution) until a pink color is obtained. Let total acid used for both titrations = T. Then 2t = c.c. of acid corresponds to the amount of carbonate present. (T–2t) c.c. of acid corresponds to the bicarbonate. Compute to CO_3 and HCO_3.

NOTES:

(a) The residue for mineral analysis should weigh from 400–600 milligrams. The weight of Total Solids, therefore, will give some idea of the amount of sample to evaporate to obtain the above amount of residue.

(b) A more accurate method for obtaining the amount of organic matter in the Total Solids would be that given in Stillman's Engineering Chemistry, 1900 Edition, page 53. The total solids, after evaporation and ignition, are moistened with distilled water, placed in an atmosphere of carbon dioxide for half an hour, dried and weighed. By the above operation the mineral matter in the sample of water is again combined with carbon dioxide, as it existed before evaporation.

(c) Should the amount of calcium sulphate present in the residue left after evaporation be quite large, some of it may fail to be dissolved. The silica must, therefore, be moistened with water, a few drops of sulphuric acid added and then enough hydrofluric acid to dissolve the silica. Evaporate to dryness, ignite and weigh. The loss in weight = silica. If the residue left after this operation weighs over 0.0005 grams, dissolve in hydrochloric acid and add to the filtrate from silica.

The above operations are carried on in a tarred platinum crucible.

Compute results to parts per million by weight (Milligrams per liter). Express alkalinity as parts of CaCO. 100,000 = 1 French degree of temporary hardness.

Express acidity as parts per million free sulphuric acid.

EXHIBIT VII

METHODS FOR ANALYZING WATER AS FOLLOWED BY THE CLEVELAND RAILWAY COMPANY

Paper by L. P. Crecelius, Superintendent of Power

Apparatus and Chemical for Boiler Water Analysis

APPARATUS

2–600 c.c. beakers with lip	$0 55
2–400 c.c. beakers with lip	40
2–250 c.c. beakers with lip	25
1 glass lamp	2 40
6–2.5 in. funnels	1 35
1–platinum crucible	20 00
2–1.5 in. porcelain crucibles	60
1–50 c.c. burette	1 50
1–500 c.c. graduated cylinder	85
2–3.5 in. orcelain evaporating dishes	55
1–water bath	1 90

APPARATUS—(*Continued*).

1–analytical balance and weights	$76 35
1–desiccator	2 00
100–S. & S. No. 589–9 cm. cut filters	80
1–Bunsen burner	22
2–6 in. porcelain evaporating dishes	1 05
1–wash bottle	35
	$111 12

CHEMICALS

Distilled water, barium chloride, nitrate acid, silver nitrate, yellow potassium chromate, sulphuric acid, ammonia, hydrochloric acid, ammonia oxalate, sodium ammonium phosphate.	5 00
Total	$116 12

THE ANALYSIS OF BOILER WATER

TOTAL SOLIDS:

Evaporate a known volume (250 c.c.) of water to dryness, in a weighed porcelain evaporating dish, on a water bath. Use an evaporating dish of such size that it can be weighed conveniently on an analytical balance. Place the dish and evaporate residue in an air bath and leave it at 100 deg. C. one hour, cool in desiccator and weigh dish plus total solids. This determination is used as a check on the total solids as calculated.

TOTAL SOLIDS AS SULPHATES:

The total solids residue is treated with a few drops of dilute sulphuric acid (enough to moisten the residue). The dish is then cautiously heated until fumes of sulphuric anhydride are given off. Then the dish is heated to redness over a bare light until the sulphuric fumes have disappeared. Then the residue, after cooling, is moistened with dilute ammonia, in order to convert any acid sulphate present to the normal salt, then the residue is heated and ignited as before, and the dish plus total solids as sulphates is weighed. The weight of this residue is used in the calculation.

SILICA:

This determination is worked only when complete analysis is called for. Warm the sulphate residue with sufficient dilute hydrochloric acid to dissolve all the sulphites. Filter and wash with hot water, ignite and weigh residue as silica.

FERRIC OXIDE:

Work only when complete analysis is called for. The filtrate from the silica determination is heated to boiling, precipitated by ammonia,

filtered, washed with hot water, ignited and weighed as ferric oxide.

Ordinarily the determinations of silica and iron oxide are omitted and the following procedure is used.

LIME AND MAGNESIA:

A known volume (250 c.c.) of water is heated to boiling in a beaker, acidified with a slight excess of hydrochloric acid to expel any carbonic acid present, boiled down if necessary to a convenient bulk, rendered slightly alakline with ammonia, filtered and precipitated by ammonium oxalate. The solution is kept about the boiling point for half an hour, the precipitate allowed to settle and then filtered, washed with hot water, ignited over the blast lamp and weighed as calcium oxide.

The filtrate from the lime is allowed to cool to room temperature, made distinctly alakline with ammonia and precipitated by sodium ammonium phosphate. Stir vigorously and let stand two hours, filter ash with 10 per cent. ammonia water, dry, filter and residue, ignite in a weighed porcelain crucible and weigh as magnesium pyro-phosphate. This calculated to magnesium oxide.

SULPHATES:

A known volume (250 c.c.) of the water is acidified with a slight excess of hydrochloric acid, heated to boiling, filtered and precipitated by barium chloride. The precipitate is allowed to stand over night, or else is kept at the boiling point for one hour, filtered, washed with one per cent. nitric acid water, ignited and weighed as barium sulphate. This calculated to suphuric anhydride.

CHLORINE:

Measure out 50 c.c. of the water and titrate against a standard solution of silver nitrate containing 1.1972 grams silver nitrate in 500 c.c. of water, of which 1 c.c. used represents 0.933 grains of sodium chloride per U. S. gallon when 50 c.c. sample is taken. Each c.c. equals 0.0005 grams chlorine. Potassium chromate indicator is 1 gram in 100 c.c. water.

BOILER WATER CALCULATIONS:

1. Convert the lime and magnesium oxides to sulphates in grams per liter and find the sum of these weights.
2. Deduct this weight from the total solids as sulphates in grams per liter, the difference found equals sodium as sodium sulphate.
3. Find sodium oxide equivalent of the sodium sulphate.
4. Find the number of grams per liter equivalent to the number of grains per U. S. gallon of sodium chloride found.
5. Find number of grams per liter of sodium oxide equivalent to sodium chloride found.

6. Deduct from the total sodium oxide (No. 3) the sodium oxide present as sodium chloride (No. 5). The balance sodium oxide, if any, is combined with sulphate as sodium sulphate so far as possible. There is generally more than enough sodium oxide to combine with all the chloride, but if there is an excess of the latter, combine it first with the lime and then with the magnesia.

7. If there is not enough sulphate to combine with all the remaining sodium oxide, combine the excess of sodium with carbonate.

8. If sulphate is in excess, combine it with lime oxide and finally with the magnesium oxide.

9. Calculate any excess of lime or magnesium oxide to lime carbonate and magnesium carbonate.

10. Calculate all ingredients first to grams per liter, then to grains per U. S. gallon, and report only the latter.

EXHIBIT VIII.

METHODS FOLLOWED IN TESTS OF LUBRICATING OILS BY THE UNITED RAILWAYS COMPANY OF ST. LOUIS

Apparatus.

Viscosimeter (home made)	$20 00
Cleveland open fire tester with thermometer and burner (home made)	12 00
Stop watch	7 50
Westphal balance	12 00
Total	$51 50

Tests of Lubricating Oil

A four ounce sample of oil is taken from the delivery and sent to the laboratory for testing. The tests that are made on all oils are specific gravity, viscosity, fire and flash. The color and freedom from water are also noted in the sample.

SPECIFIC GRAVITY:

The specific gravity is determined by means of a Westphal balance and the result changed into Baumé degrees by the use of a table.

A Westphal balance works well with a four ounce sample and may also be used for liquids heavier or lighter than the lubricating oils.

The oil to be tested is placed in the cylinder, furnished with the instrument. The balance is then set up on a level table. The cylinder containing the oil is then brought under the plummet and the required riders are added to restore equilibrium. The position of the largest

rider, on the beam, represents the first decimal, the next the second, etc.

The temperature of the oil in the cylinder is noted and a correction made; if the temperature of the oil is not 15.5 deg. C., which is rarely the case with heavy stocks. These must be warmed to about 35 deg. C. before taking the gravity. Care must be used to keep the plummet from touching the sides of the container.

VISCOSITY:

Viscosity refers to the body or fluidity of an oil. This determination is made with an instrument called a viscosimeter. An efflux type of viscosimeter is used. This is illustrated in the drawing. (See Fig. 3, p. 19, of this report.) Below are given several points to be observed in the operation of any efflux type of instrument.

(a) The temperature of the bath should be uniform throughout. (The temperature of bath varies with the type of instrument.)

(b) The oil sample should be strained before putting it into the instrument.

(c) Stir the oil in the instrument and take readings until the temperature of the oil and water bath are the same.

The manipulation of an efflux type of instrument used in this laboratory is as follows:

1. Bring the water bath to the required temperature, 100 deg. Fahr. for engine oils, and 212 deg. Fahr. for cylinder stocks, heavy black oils, etc. Keep the bath at the proper temperature throughout the test.

2. Heat the sample of oil to be tested in a small cup, to about the required temperature.

3. Clean out the oil cylinder with the plunger.

4. Place the cork (as little distance as possible) in the lower outlet tube, just enough to make air tight, but not far enough to touch the small outlet tube.

5. Then pour oil from the heating cup through a fine wire strainer into the oil cylinder until the same overflows.

6. Put thermometer into oil and stir until standard temperature is reached.

7. Take thermometer from oil; withdraw excess of oil from the overflow cup with a pipette.

8. Then place the 60 c.c. graduated flask under, and in line with, the efflux tube of the oil-cylinder.

9. Withdraw the cork and start stop watch at the same time.

10. The number of seconds required for the delivery of 60 c.c. of oil is the viscosity.

FLASH AND FIRE:

The flash and fire apparatus consists of an open brass cup, heated on a sand bath. A thermometer for taking the temperature of the oil and a burner for heating. Also, a small ⅛ in. flame for testing. The testing flame is about ⅛ in. long and may readily be made by burning gas at the small end of an ordinary blow pipe.

The sample, after the determinations of specific gravity and viscosity, is put into the flash cup which is filled to about ⅜ in. of the top. The thermometer is inserted in the oil so that all of the bulb is immersed. The burner is lighted and the oil heated 12–15 deg. C. per minute until a temperature of 150 deg. C. is reached. Apply the test flame by passing diametrically across and about ⅛ in. above the surface of the oil, for every 5 deg. C. rise of the thermometer. Continue the heating and testing until the vapor from the oil ignites with a slight flash. The temperature given by the thermometer is the flash point, of the sample.

Continue heating and testing until the oil ignites and burns freely on application of the test flame. This temperature is the fire point.

Cold tests, tarry matter and suspended matter, and free acid tests, percentage of animal oil in mineral oils, etc., are made according to standard methods to be found in:

"Oil Analysis," by A. H. Gill;

"Chemical Technology and Analysis of Oils, Fats and Waxes," by Julius Lewkowitsch.

EXHIBIT IX

METHODS FOR TESTING OILS AS FOLLOWED BY THE CLEVELAND RAILWAY COMPANY

Paper by L. P. Crecelius, Superintendent Power.

Lubricating Oil Analysis

SAMPLING:

One sample each of engine and cylinder oil is taken as an average of each month's shipment. A ¾ in. hole is bored through the bung of each barrel (of about 50 gal. capacity), a ⅜ in. (inside dia.) glass tube inserted and suction applied throughout the various strata of oil to fill the tube. About the same quantity of oil (2 or 3 tube fulls, depending upon the number of barrels) is taken from each barrel until a two-quart sample jug is filled.

FLASH TEST:

This test is made with a Cleveland Open Fire Tester, which consists of a round brass cup (about 3 in. diameter and 1½ in. deep) flanged to rest on an air bath (also of brass), the whole being supported over a Bunsen burner with suitable adjustments for holding a

750 deg. Fahr. thermometer in the oil cup. The original cup and thermometer supports not being entirely satisfactory, universal movement clamps were substituted, together with an asbestos shield, rendering the stirring and heating of the oil much more easy. The oil cup is filled to within ¼ in. from the top with thoroughly stirred engine oil (or ½ in. from top with cylinder, because of extra expansion of latter), and the thermometer so adjusted that the bulb is ¼ in. from bottom of center of cup, and entirely covered with oil. The oil is now heated rather rapidly to about 300 deg. Fahr. and then the rate of rise reduced to from 8 to 14 deg. Fahr. per minute. The oil in question flashes at about 415 deg. Fahr., and is tested every 5 deg. rise (commencing at about 350 deg. Fahr.) by passing a ¼ in. gas flame (obtained by inserting a piece of glass tubing drawn to a point, in the rubber gas hose) slowly back and forth ½ in. above the middle of the oil cup. The flash point is the temperature at which the oil will flash straight across the middle of the cup.

The cylinder oil is heated up to 450 deg. Fahr. before cutting down the rate of rise to about 10 deg. per minute, and is tested as in the case of engine oil, commencing at 500 deg. Fahr., the oil in this case flashing at 550 deg. Fahr. upwards.

BURNING POINT:

The heating of the oil is slowly continued, after it flashes, testing as before until the oil burns steadily, and the flame must be blown out. The burning point is approximately 10 per cent. of the flash test, and in the cases of the above oils is about 450 deg. Fahr. for engine and 615 deg. Fahr. for cylinder oil.

SPECIFIC GRAVITY:

The gravity is taken in degrees Beaumé, 10 deg. (at 60 deg. Fahr.) corresponding with specific gravity of 1, the gravity becoming less as the Beaumé degrees increase. The engine oil (referred to in this article) is in the neighborhood of 31 deg. Beaumé and the cylinder oil about 26 deg. Beaumé.

The oil is well mixed, poured into a hydrometer jar, the hydrometer (with thermometer attached) inserted and allowed about 15 minutes to come to an equilibrium. (In the case of heavy cylinder oils it is well to heat up the sample to 80 deg. Fahr. or more in order that the hydrometer may sink properly.) At the end of this time, the readings are taken (both hydrometer reading and thermometer reading), allowing for the oil meniscus on the gravity reading. Referring to a table at hand the indicated figure Beaumé degree is corrected for temperature of oil, deducting for 61 deg. or higher and adding if below 60 deg. More accurate but more complicated work may be done by using specific gravity bottles.

VISCOSITY:

A Tagliabue Viscosimeter is used for this determination. This is an instrument for measuring the length of time it takes a fixed quantity of oil at a certain temperature to run out of a small opening. This body or viscosity of the oil is determined on engine oil at 70 deg. Fahr. and on cylinder oil at 212 deg. Fahr.

In the engine oil test the larger or 70 deg. tip is screwed onto the bottom of the cylindrical water jacketed oil cup, and into the latter is measured 90 c.c. of well mixed, strained oil at a temperature as near 70 deg. Fahr. as possible. By adding cooler or warmer water (as the case may be) to the water jacket, the temperature of the oil is brought to exactly 70 deg. Fahr. This figure is obtained from a thermometer (50–100 deg. in 1 deg. divisions) suspended in the oil so that the bulb is ¼ in. from the bottom. The thermometer also serves as a stirring rod. When the oil temperature has remained uniform for one minute, the cock is opened and a stop watch started simultaneously. When exactly 70 c.c. of oil have run out into a 70 c.c. flask the oil flow and watch are stopped, the number of seconds of time noted and this figure doubled to obtain the viscosity figure.

In determining the viscosity of cylinder oil, the latter is first heated to 220 deg. Fahr., strained and 80 c.c. of it poured into the oil cup to which the 212 deg. or smaller tip has been attached. In this case the oil cup jacket is used as a steam instead of a water jacket, steam being generated by means of a water boiler and (Bunsen burner) connected with the jacket by a small valve. It takes some time to get up steam, and in the meantime the mixing, heating and straining of the oil, etc., is done. Some trouble is experienced in obtaining a uniform temperature of 212 deg. Fahr. in the oil due to the elevation, weather conditions and radiation, but this may be overcome by adding enough glycerine to the boiler water to boost the temperature of the oil to 212 deg. Fahr. The viscosity with cylinder oil is determined as in the case of engine oil, except that 60 c.c. of oil are run out into a 60 c.c. flask instead of 70 c.c.

Between two determinations the jacket is cooled with wet cloths and the oil cup cleaned out thoroughly with gasoline. The various pieces of glassware used in this operation must be cleaned in the same manner and let stand to dry, as wiping with a cloth leaves lint which may tend to increase the viscosity by partially stopping the oil opening. Duplicate tests should check within 4 points or two seconds.

ANIMAL OIL:

Qualitative Test:

The presence of animal (or vegetable) oil in engine oil may be detected by adding a small piece of sodium hydroxide to a test tube one-quarter filled with oil sample and boiling over a Bunsen flame.

If the oil, when cool, is more viscous than originally, more or less animal oil is present. This is due to the formation of soap. About two per cent. of saponifiable oil in a sample will make thick jelly, so the amount of such oil present may be approximated by heating as above, and diluting repeatedly with proportionate quantities of pure hydrocarbon engine oil until the resultant mass is liquid.

Quantitative Test:

An Erlenmeyer flask of 200 c.c. capacity is washed, dried and into it weighed (by difference) about ten grams of oil sample. 25 c.c. of half-normal alcoholic potash solution is added to this from a burette, then 25 c.c. of neutral alcohol and 50 c.c. of purified benzine. Two tests are run on a sample and two sample determinations and a blank (potash solution, alcohol, benzine, but no oil) are carried on simultaneously. These flasks and contents are now connected up with Sohxlet extraction apparatus, and heated on electric hot plates for an hour and fifteen minutes. Using benzine and alcohol instead of alcohol alone as in the old method reduces the time of boiling from six hours. The reason for this is that the benzine dissolves out the mineral oil giving the potassium hydroxide a better chance to saponify the animal oil. The apparatus above referred to is an arrangement of glass tubes and series condensers by which the alcohol and benzine vapor (produced in boiling) is condensed by running water and accumulated in a pocket up to 60 c.c., when it is automatically syphoned into the flask again. In this way the action of the potash is concentrated and the contents of the flask stirred up every seven minutes.

After saponification the flasks of oil (and blank) are corked, cooled and titrated with half-normal hydrochloric acid, using phenolphthalein as indicator. This titration must be carried on very slowly, as the addition of each drop of acid and consequent shaking necessitates a wait of about two minutes until the two layers (benzine-mineral oil and alcohol-soap-alkali-salt) separate, so that any change of color may be seen.

The weight of KOH originally taken minus weight left at end of operation (figured from No. c.c. acid required) gives weight of KOH used to saponify animal oil. From this difference must first be subtracted the weight of KOH used up in the blank, before per cent. of animal oil is calculated. To obtain the latter figure the weight of KOH (c.c. used in titration $\times$ weight per c.c.— 28.054 mgs. for N/2 KOH) is divided by the weight of oil taken and the dividend (Wt. of KOH used per gram of oil) divided by 195 to find percentage of oil. From experiment the figure 195 has been taken as the average number of milligrams of potassium hydroxide necessary to saponify one gram of animal oil used in lubricating oils.

FREE ACID:

Fifteen grams of oil are weighed up, as before, into an Erlenmeyer flask, 50 c.c. of neutral alcohol added, the whole boiled for a minute, cooled and titrated as before, using tenth normal potassium hydroxide solution. In the calculation 205 is used as the acid figure for cylinder oil (the free acid being mainly organic and the mineral acid being represented in negligible quantity) and 1143 the acid figure for engine oil, sulphuric acid constituting the free acid.

EXHIBIT X

DR. CLARK'S SOAP TEST FOR HARDNESS IN BOILER WATERS

Stock Soap Solution

Castile soap shavings..... 20 grams.
Alcohol . . . . . 350 c.c.
Distilled water to make..... 500 c.c.

Dissolve soap shavings in the alcohol on a steam bath, then add the water.

Standard Soap Solution

Stock soap solution..... 200 c.c.
70 per cent. alcohol to make..... 1000 c.c.

Standardize with calcium carbonate as follows: 2000 grams $CaCO_3$ dissolved in little HCl and distilled water to make one liter (20 parts per 100,000). Evaporate to dryness, add a small amount of distilled water and evaporate to dryness again. Add distilled water to make one liter. 3.6 c.c. of Standard Soap Solution should lather 10 c.c. of $CaCO_3$ solution.

Analysis

The method of analysis is based on 50 c.c. of water to be tested. In a well stoppered bottle of about 250 c.c. capacity put 50 c.c. of water to be tested, shake briskly a few seconds, add standard Soap Solution from a burette ½ c.c. at a time at first and then less later, shake after each addition until a soft lather is obtained which when the bottle is placed on its side and at rest will remain continuous over the whole surface 5 minutes.

When more than 8 c.c. of soap solution are required by the 50 c.c. of water a less quantity, as 25 or 50 c.c., should be used and the result multiplied by 2 or 4.

Attached is Clark's Table of Hardness (see also Sutton's Volumetric Analysis).

10 c.c. of $CaCO_3$ solution with 40 c.c. of distilled water, if soap solution is correct, should require exactly 3.6 c.c. of the latter. Opposite 3.6 under soap heading is 4.0 under $CaCO_3$ heading. Since only 10 c.c. were taken, this multiplied by 5 gives 20, or 20 parts per 100,000, the

strength of the standard solution. Hence soap test, as outlined, will show the hardness of a water in parts per 100,000 in terms of $CaCO_3$. (Molecular weight 100.)

To convert to $CaSO_4$ multiply by 1.36.

To convert to $MgSO_4$ multiply by 1.20.

Total hardness minus alkalinity or temporary hardness equals the sulphate or permanent hardness, in terms of $CaCO_3$

To determine the alkalinity or temporary hardness, titrate 100 c.c. of filtered water with 1/50th normal sulphuric acid, using methyl-orange as an indicator. Each c.c. required represents 1 part per 100,000 of carbonate hardness or alkalinity or $CaCO_3$. Then subtract as above.

CLARK'S TABLE OF HARDNESS

(Parts per 100,000)

C. C. soap solution	$CaCO_3$ parts per 100,000	C. C. soap solution	$CaCO_3$ parts per 100,000
0.7	0.00	1.9	1.82
0.8	.16	2.0	1.95
0.9	.32	2.1	2.08
1.0	.48	2.2	2.21
1.1	.63	2.3	2.34
1.2	.79	2.4	2.47
1.3	.95	2.5	2.60
1.4	1.11	2.7	2.86
1.5	1.27	2.8	2.99
1.6	1.43	2.9	3.12
1.7	1.56	3.0	3.25
1.8	1.69		

APPENDIX C

BOILER SETTINGS

By L. P. Crecelius.

During the past few years enormous strides have been made in the economic increase of boiler capacity over the usual and customary rating as laid down by the American Society of Mechanical Engineers.

This has been the outcome of logical and scientific study concentrated upon furnace conditions. This study in the main had two important objects in view:

(1) Improvement in effective economy.

(2) Increased capacity.

At this point it may not be out of place to add that a third condition is at present undergoing investigation, viz., the application of means for making the boiler a more variable unit in its operation, by means of continuous records or indications of operation, such as measurement of fuel, water, steam, temperature of exhaust gases, CO_2, etc.

The subject, "Boiler Settings," is a very broad one and this report has been narrowed down to include only that part of the setting which is embraced by the furnace, particularly the furnace linings. That part of the boiler setting embracing the furnace has undergone considerable change, and it is now no uncommon sight to see the furnace projected out to a distance greater than the length of the stoker. The object being to increase the distance from the point where the fuel is admitted, to the tubes, as much as possible.

In very recent installations such as in the new power plants of the Boston Elevated Railway Co. and the Detroit Edison Co., the furnaces instead of being projected, are installed entirely under the boiler, but the space between the grate and the tubes is made very large to provide ample room for combustion.

In the case of the former installation where horizontal water tube boilers are employed, this space amounts to fully 12 feet; in the latter case the use of Stirling boilers, provides an enormous combustion chamber. And therefore, in both cases the necessity of maintaining large and expensive arches, is dispensed with.

Other improvements in boiler settings are insignificant in comparison, and in respect to baffles, arrangement of gas passes, etc., almost every smoke inspection office of the various cities having jurisdiction, propose, and in some cases insist upon designs including a horizontal baffle or arch directly over the furnace. These restrictions are required mainly to correct improper existing conditions, and it is believed that had the boilers been set high enough in the first instance more freedom in the choice of the proper arrangements for gas passes and baffling would be permitted.

In some recent tests made by the writer upon archless furnaces which were operated continuously to produce 200 per cent. of boiler rating, for the purpose of determining limitations to successful operation of this character, it developed that the ordinary fire brick linings of the furnace were subjected to enormous deterioration. Another difficulty developed in the fusing of the ashes to the side and bridge walls, just over the grate surface. A mass of fused ashes would accumulate until it extended all along the face of the walls parallel with the grate and stick out for a distance in some cases of over 24 in., interfering with the forward movement of the fuel and being extremely difficult to remove.

The furnaces under test were operated with forced draft at a pressure of about four inches of water which was maintained under the fire. The combustion under this circumstance is intense and great quantities of small particles of coal are continually thrown by the blast against the incandescent surfaces of the furnace where they stick. The ashes from these particles of coal melt, and containing a comparatively large amount of iron which combines readily with the silica of the hot brick at critical temperatures, soon carries down the whole surface to the grate. The violence with which this action occurs depends upon two factors: furnace temperature and character of fuel. A fuel having ash which is comparatively free of iron gives less trouble in this respect than one containing more iron; again, when boilers are operated at low rates and consequent low furnace temperatures, the poorer fuel may be burned without serious trouble in this respect. However, because excessive furnace temperatures are required and desired for smokeless combustion when forcing boilers to respond to heavy overloads, all furnace linings are subject more or less to heavy deterioration.

The best quality of fire clay brick contains in composition over 52 per cent. silica (SiO_2) and less than 43 per cent. alumina (Al_2O_3), the balance consisting of iron, lime, magnesium and alkalies. Tests have indicated the excessive silica content to be responsible for the deterioration. Special brick made of Bauxite, $Al_3O(OH)_4$, instead of fire clay which by analysis show silica, (SiO_2) less than 32 per cent. alumina (Al_2O_3) more than 65 per cent. have been secured and installed experimentally in furnaces. Furnaces so lined have been in operation many months, and the linings have overcome to a considerable extent the previous difficulties.

The following analyses are included, by reference to which, will be noted the enormous absorption of silica by the molten ash mass in running down the hot surface of ordinary fire brick linings, and on the other hand illustrates the resistance to absorption offered by Bauxite linings. Both furnaces were operated under the same conditions with reference to capacity and character of fuel. An analysis of the pure ashes of the fuel is also included.

TABLE SHOWING ANALYSIS OF ASH IN PER CENT.

	Case 1.	Case 2.	Case 3.
Silica	38.80	50.40	39.35
Alumina	23.83	25.19	24.17
Iron Oxide	27.83	15.72	27.60
Lime	6.86	5.34	5.98
Magnesia	0.66	0.83	0.90
Alkalies	2.02	2.20	2.00
Combustible	0.00	0.32	0.00

Case 1. Analysis of pure ash taken from typical coal sample.
Case 2. Analysis of molten ash mass which has run down hot surface of ordinary fire brick furnace lining.
Case 3. Analysis of molten ash mass which has run down hot surface of Bauxite furnace lining.

It is highly essential to provide large combustion chambers over furnaces that are intended for over-loading, not alone for the purpose of supplying space for flame, because with forced draft furnaces this is unnecessary, but for a more important reason, viz., to secure high initial temperatures. A high temperature makes possible the use of a minimum amount of air to be supplied to the furnace. Therefore, the cooling influence of the boiler surface must be sufficiently removed to prevent the rapid absorption of radiant heat as only by this means can high furnace temperatures be secured.

Since the critical temperatures for ordinary furnace linings appears already to have been reached, it seems that future development to further and successful forcing of boilers must be accomplished by means by the archless type of furnace. This becomes more apparent when one reflects that vertical furnace linings are more easily and cheaply maintained, than in the case of large horizontal over-hanging surfaces.

MR. KELSAY:— The first subject for consideration is the Method of Selecting Faulty High Tension Cables at the Power House. This will be presented by the chairman of the subcommittee, Mr. Sawyer.

Discussion of Report of Committee on Power Generation

MR. SAWYER:—The subject for your attention is Method of Selecting Faulty High Tension Cables at the Power House, not the prevention, the selection to be automatic or otherwise. The paper is very short, but the the time is possibly shorter and I will just make a brief abstract.

PRESIDENT ACKERMAN:— Gentlemen, we now have the subject of this report before us, and would like to hear from any who care to enter into discussion.

MR. SAWYER:— This is a new subject, and the situation is not in such shape that a definite recommendation could or

should be made, and for the present, the Committee felt it would be sufficient to review the situation by giving the present status. One of the objects of this paper is to try to bring to the attention of manufacturers the conditions as they now exist, to show the real need for either new designs, or for the manufacturers to co-operate more closely with the railway engineers, in order that more satisfactory results may be obtained. I should like to know whether in general the condition is as outlined, and, if so, what the manufacturers have to suggest.

PRESIDENT ACKERMAN:— If there is no discussion, gentlemen, we will pass on to the next subject.

MR. KELSAY:— The next subject for consideration is that of Chemical Laboratory Practice in Connection With Power Plant Work. This subject is a practical one and exceedingly interesting, and in my opinion most valuable. Mr. Hobein, chairman of the subcommittee will review this paper.

MR. HOBEIN:— The Committee on Power Generation felt that this subject had better be taken up under three considerations; the first with respect to the companies who operate large urban systems; second, the smaller companies, or fairly large interurban systems, and third, small systems.

(Mr. Hobein abstracted that part of the report covering Chemical Laboratory Practice.)

MR. HOBEIN:— These reports have been prepared by the different companies. The report of the United Railways Company of St. Louis was written up by our chemist, who makes a few remarks on the various tests and outlines the distinctive features of the several methods. He also considers some of the apparatus used and points out some of the troubles and good points of the different types of apparatus.

Under "Water Analysis," I will say in investigating this subject, there was found to be quite a difference in the methods of reporting the results of the analysis. It appeared to me that the subject was of considerable importance so the matter has been elaborated in this paper and quotations cited from different articles that have come to my attention during the investigation. The chief trouble seems to be that a sample of water may be sent to two different chemists and from the results their reports apparently indicate that they are not report-

ing on the same water. I recently ran across an article in the *Engineering News* on the mineral analysis of water, by Herman Stabtler, in which he takes up the question of the analysis of water and gives different formulae by means of which the amount of foaming liable to occur is determined and also the amount of scale liable to be formed by the water and the quantity of chemicals necessary to soften the water. Then there are some other tables which, I thought, might be of value for reference. Referring now to the practice of companies of the second class: The water analysis is quite an exact method, and the chances are that an experienced chemist would be necessary to carry out the analysis of water. However, there are tests using simple methods and given in the exhibits, by which companies can determine the amount of hardness in water. These give a very good check on water, as regards the amount of scale which is likely to obtain. The other day an engineer at one of our plants had some trouble with his down-draft furnaces, due to leaks. He had been using water without practically any scale forming material. In that plant there is a well, which had not been used for several years and he wanted to use some of that water, thinking it would cure his ills. Consequently we had our chemist make comparative tests on the city water and also the well water to determine their degree of hardness. The hardness in the well water was about four or five times that of the city water.

The most beneficial thing that companies of the third class could do with the laboratory work, would be testing oils. By means of simple tests they might be able to save themselves a great deal of oil, and the report gives a hypothetical case illustrating this point.

I was very much pleased to receive so many replies to my letters of inquiry, and I have included quite a few of the different methods in this paper.

MR. HANNA:— While I have not had an opportunity to carefully digest this report, from the field that it covered and the subjects entered into, it appears to be one of the most valuable reports we have ever had. The work that has been devoted to it will surely be appreciated and recognized.

Mr. Roberts:— This paper is of exceedingly great value to the Association in general, but I am particularly interested in it. Of course we have now come to a place where we are largely controlled not so much by the doctrinal part of this paper as the ethical deductions. Recently Mr. Lathrop and myself visited quite a number of power plants in the East. We wanted to look into various matters, such as an analysis of coal, water and oil, and of all of the plants visited there was only one, and that private in its nature, that kept complete and continuous records of these analyses. There was also only one plant that we visited that kept the CO_2 recorder in working condition, but in nearly every plant that we visited we found some description of a CO_2 recorder, that was allowed to stand by the wall. We also recently visited plants in the West and found the same conditions to exist. Now, to my mind there is scarcely any instrument that requires less attention than a CO_2 recorder. It does not require half the attention that a boiler does, yet there is nothing so instructive. I have found, since placing these CO_2 recorders in our plant, that the men are doing exactly what I predicted twelve months ago in our meeting, that is, that they are gradually overcoming their carelessness and are using the best methods of firing and are trying to produce the greatest amount of steam from the least amount of coal. You would be surprised to know the number of men who are trying to show the best card when the examination comes in the morning. The largest companies, the medium sized companies, and even the smaller companies, will find later on that it is absolutely necessary to have some one make these analyses and make them correctly. In one very large plant that Mr. Lathrop and I visited we found the CO_2 recorder out of commission, and when we asked the men how they secured their records, one of them pointed to an Orsat analyzer at the end of the boilers and said, "We get all we need out of that." I asked him, "What value is that to you? You have only an idea of what has been done during the twelve hours, you have no tests of the men, you do not know what shift has fired correctly or incorrectly, and you cannot determine who has emitted or admitted too much air."

If they had had a CO_2 recorder test there would be something reliable upon which to base results. I do not deem that all these conclusions are correct, because you may take a sample of coal, under the best possible conditions, and send it to two different chemists, and you will have different reports. The same conditions also exist with reference to the oil and the water. We have made tests and found this to be so, but the period in our history is gradually approaching when these matters, which seem now to belong to the laboratory of our system, will be taken care of in the power house. We were given directions to buy everything that we could to make our power house the very best, but when we came back from the East we had not purchased anything. There was one plant in New York where a record was kept of everything consumed in the place and although the plant was smaller than that of the company which supplied light and power to the city consumers, the result of keeping these continuous records and making every effort to keep the plant in perfect condition showed that power could be generated at a lower cost per kw-hour than in any plant in New York, and as a consequence, is absolutely independent and able to meet competition.

This paper provides food for all of us. It is a meaty proposition. There is not a single thing here that is not within the region of common practice — you and I can take these things up. I do not want to say anything in the shape of a plagarism here, but do want to express the thought that we all desire to "make the mechanic a better man and the man a better mechanic." I think if we give the men nice clothes, lockers, shower baths, good fire rooms, painted boilers, keep everything decent and respectable, that we will find a marvellous difference in the same men under different conditions. I think the Committee deserves our very best thanks for the great amount of labor involved in the preparation of this paper.

Mr. Cahill:— I think this paper shows the general tendency of modern power plant practice. Our coal requirements for the year 1912 are practically 185,000 tons. For four years past we have bought coal on the B. T. U. basis.

Consequently we have to run a laboratory. We started in a small way, and gradually enlarged, so that the laboratory now does a large amount of outside work, in fact it is paying practically all expenses. The matter of testing coal is of vital importance. In our case the total coal cost is about 78 per cent. of the total operating expenses of the plant, and you have to keep after the coal to make a showing that amounts to something. We test oils, cements and pipe covering, also make physical and chemical tests of all metals, etc.

While it is generally conceded to be something of a slippery nature, I would state that with us oils run more uniformly than anything we buy. We do not buy by brand, but by specifications, covering certain physical characteristics. Much better results have been had since we began to make these tests and shippers began to know that every consignment of oil would be tested. While it is desirable to save in this as in everything, oil is only a little over 1.5 per cent. of the total operating expenses.

It is well to keep in mind that the tendency of power plant operation is along more scientific lines than heretofore and it is in the boiler room that we have to put our efforts. There has been too much lost through turning the boiler room over to an inferior grade of men; where three-fourths of your money is spent in the boiler room, as in the larger plants, it is economy to have some one who is thoroughly competent supervising the work.

MR. KELSAY:— Mr. Crecelius has been called away, is therefore unable to present his report and Mr. Litchfield has kindly consented to read it for him.

(Secretary Litchfield then read the report prepared by Mr. Crecelius on Boiler Settings.)

MR. HANNA:— Mr. President, I move you that the Report of the Committee on Power Generation be approved and adopted, and that a vote of thanks be tendered to the Committee for their most excellent work.

(Motion duly seconded, stated and unanimously carried.)

On motion duly made and seconded the meeting was then declared adjourned.

THURSDAY MORNING SESSION

OCTOBER 10, 1912

JOINT MEETING OF ENGINEERING AND ACCOUNTANTS' ASSOCIATIONS, BROWN ROOM, SADDLE AND SIRLOIN CLUB.

The meeting was called to order at 10:10 A. M., President Ackerman of the Engineering Association in the Chair.

PRESIDENT ACKERMAN:— We have been holding our train, gentlemen, for Mr. Young, President of the Accountants' Association, but he has not yet arrived. Is Mr. Hixson, First Vice-president, here? Is Mr. White, Second Vice-president, present, or Mr. Stubbs, the Third Vice-president? (There was no response.) I am afraid we cannot start without both sections of our train, gentlemen, as neither the President nor one of the vice-presidents of the Accountants' Association is present.

(Moved and seconded that Mr. M. W. Glover, of the Executive Committee of the Accountants' Association, act for the Accountants' Association.)

(Motion carried; whereupon Mr. Glover took a chair at the table.)

PRESIDENT ACKERMAN:— Gentlemen, as you know, this is a joint session of the Engineering and Accountants' Associations, at which two joint committees are to present reports. The first report will be that of the Joint Committee on Engineering Accounting. I will call on Mr. Lasher to come forward and present that report.

REPORT OF THE JOINT COMMITTEE ON ENGINEERING ACCOUNTING

To the American Electric Railway Engineering and the American Electric Railway Accountants' Associations:

Gentlemen:— During the past year your Committee has held two meetings, the first of which was on January 26, 1912.

At this meeting there were present: Messrs. F. B. Lasher, New York City, *Co-Chairman,* and J. C. Collins, Rochester, N. Y., from the Accountants' Association, and Messrs. H. H. Adams, New York City, and John Sibbald, Gloversville, N. Y., of the Engineering Association. Mr. P. S. Young, president of the Accountants' Association, was also present.

At this meeting the following subcommittees were appointed: Committee on Inter-department Charges — Messrs. J. H. Hanna, Washington, D. C., C. E. Thompson, Chicago, Ill., and A. F. Elkins, Columbus,

Committee on the Subdivision of Maintenance of Equipment Accounts — Messrs. John Sibbald, F. B. Lasher and J. C. Collins.

Committee on Collection and Compilation of Rules for Depreciation — Messrs. F. B. Lasher, J. C. Collins and M. J. French.

The subject of Scientific Management was discussed thoroughly, and was assigned to the entire Committee.

A second meeting of the Committee was held at the Association headquarters on July 15, 1912.

There were present: Messrs. F. B. Lasher, *Co-Chairman,* J. C. Collins and J. M. Joel, representing the Accountants' Association, and Messrs. H. H. Adams, John Sibbald, and M. J. French representing the Engineering Association.

SUBDIVISION OF THE MAINTENANCE OF EQUIPMENT ACCOUNTS

In the report presented at the 1911 meeting the Committee recommended a number of sub-accounts which the companies could adopt to supplement their use of the standard classification prepared by the Accountants' Association. The sub-accounts related to the operating maintenance expense accounts and did not affect in any way the primary accounts of the Standard Classification. They were designed to provide the fuller details regarding charges to maintenance accounts that are necessary on many railroads.

This year the Committee, in its consideration of the general subject of maintenance accounts, calls attention to the advantage of an exact division between the maintenance of rolling stock and maintenance of power plant accounts. Under the present standard classification of operating expenses, expenditures chargeable to the general account "Equipment" cover both rolling stock and power plant and no natural complete division as between these two important classes of expense is afforded; that is to say, the Maintenance of Equipment charges as prepared afford no separation of the expenses as between power plant and rolling stock. The Committee feels that it is desirable that such analysis should be provided by the classification, and therefore recommends that the general account "Equipment" be divided into two classes of primary accounts, one dealing with power plant maintenance and the other with rolling stock maintenance. With this subdivision there would be two groups under the general account "Equipment," as follows:

II. EQUIPMENT:—

GROUP I — POWER PLANT EQUIPMENT

Superintendence of Power Plant Equipment.
Power Plant Equipment.
Substation Equipment.
Depreciation of Power Plant and Substation Equipment.
Other Operations — Dr.
Other Operations — Cr.

GROUP II — ROLLING STOCK EQUIPMENT

Superintendence of Rolling Stock Equipment.
Passenger and Combination Cars.
Freight, Express and Mail Cars.
Locomotives.
Service Cars.
Electrical Equipment of Cars.
Electrical Equipment of Locomotives.
Shop Machinery and Tools.
Shop Expenses.
Horses and Vehicles.
Other Miscellaneous Equipment Expenses.
Depreciation of Equipment.
Other Operations — Dr.
Other Operations — Cr.

It will be noted that the foregoing suggestion would divide the present primary account "Superintendence of Equipment" into two primary accounts, one covering the Superintendence of Power Plant Equipment and the other covering the Superintendence of Rolling Stock Equipment.

In order to be consistent the classification, if it is to divide the superintendence of equipment as between power plant and rolling stock, should also divide the Superintendence of Transportation as between power and operation of cars under the general account "Conducting Transportation." The Committee, therefore, suggests for consideration in connection with the changes proposed in the general account "Equipment" the following classification for "Conducting Transportation:"

IV. CONDUCTING TRANSPORTATION:—

GROUP I — POWER

Superintendence of Power.
Power Plant Employees.
Substation Employees.
Fuel for Power.
Water for Power.
Miscellaneous Power Plant Supplies and Expenses.
Lubricants for Power.
Substation Supplies and Expenses.
Power Purchased.
Power Exchanged — Balance.
Other Operations — Dr.
Other Operations — Cr.

GROUP II — OPERATION OF CARS

Superintendence of Transportation.
Passenger Conductors, Motormen and Trainmen.
Freight and Express Conductors, Motormen and Trainmen
Miscellaneous Car Service Employees.
Miscellaneous Car Service Expenses.
Station Employees.
Station Expenses.
Car House Employees.
Car House Expenses.
Operation of Signal and Interlocking Systems.
Operation of Telephone and Telegraph Systems.
Express and Freight Collection and Delivery.
Loss and Damage.
Other Transportation Expenses.

It is recommended by the Committee that this part of the report be referred to the Committee on a Standard Classification of Accounts and Form of Report of the Accountants' Association for consideration.

RULES FOR DEPRECIATION

This Subcommittee was asked to gather such data as might be available as to the practice of certain companies in the treatment of Depreciation, and it has been able to collect considerable information which is in the hands of the Secretary of the Association for the use of Member Companies.

SCIENTIFIC MANAGEMENT

In continuing the work of the previous year your Committee has given further attention to the subject of Scientific Management on electric railways. It assumes that what is meant by Scientific Management, or, as it is sometimes termed, efficiency engineering, is economical management or standardization of efficient methods. Each company pursues its own policies in this respect, and many of the practices which are being introduced by the so-called efficiency engineers have been followed in principle on electric railways for a number of years.

The Committee believes, however, that there is room for progress through careful analysis of these methods and their gradual standardization to meet the needs of all properties, small as well as large. For that reason it sent a letter to a selected list of company members. This letter asked for information and data regarding results that have been secured by the use of efficient methods, and that the answers be segregated as between the Maintenance of Way, Power Plant, Overhead Lines and Cables, and Maintenance of Equipment Departments.

A number of replies were received, and in the majority of cases it was found that there was no standard from which comparisons

could be made. The Committee, therefore, reached the conclusion that while work of great value is being done by individual companies, the Association has a wide field for labor before it in the collection of information regarding methods that have yielded good results on individual systems and may be adapted and standardized for general use.

Among the companies that are making a systematic study of their affairs so as to attain greater economy of operation and maintenance is the Boston Elevated Railway Company. This company has an Efficiency Club and an Efficiency Committee, composed of some of its general officials and responsible heads of departments and these organizations meet periodically. In addition to the work conducted through these agencies similar studies are made by individual departments. In order to illustrate the methods which are followed in the Rolling Stock Department your Committee presents as Appendix A of this report the reply which it received from the Boston Elevated Railway Company, giving many details of interest.

Other possibilities for improvement exist. The Committee has considered some of the efforts made to effect economy in the use of power. Various methods can be used to encourage the motormen to be economical in the use of power. There are several devices on the market for recording the performance of individual motormen. These afford a method of comparison. In the investigation of this subject the Committee learned that savings have been accomplished by careful instruction of motormen in regard to the consumption of power by cars. By systematic obedience to the instructions, economies reaching as high as 10 per cent. on the total consumption of power have been reported.

To illustrate one method that has been employed to effect greater economy in the use of power in the operation of cars, even without the use of mechanical means, the Committee submits herewith circulars which have been issued to the employees of the Public Service Railway Company of Newark, N. J.

The Committee realizes that this is only one of a number of suggestions for economy that can be adopted in various departments of electric railways and improved from time to time without the necessity of investment in apparatus.

It is the earnest recommendation of this Committee that member companies, in connection with the study of economical management and efficient methods, give further study to the subject of the economical use of power.

COST ACCOUNTING

Economical management should be accompanied by detailed cost accounting. The Committee believes that costs of shop work and other departmental expenses should be kept in full detail in order

SAVE THE POWER

Useless waste of power is burning up thousands of good American dollars every year.

COASTING CARS CUT CURRENT COST

Every foot a car coasts without power is so much current saved.

SAVE THE POWER

The motorman who notches his controller properly is on time oftener than the one who hits the button and blows the breaker.

SAVE THE POWER

Fast feeding of controllers wastes the current and damages the equipment.

SAVE THE POWER

Text of Circulars Issued by the Public Service Railway Co., of Newark, N. J.

that the management may know the exact expenditure for different classes of work. The advantage of this is that it enables the company to make a study of the various operations so as to establish standards of time for the different jobs. If the costs of existing work are determined and reduced to a unit basis, it is a simple calculation to fix the time required for specific jobs. With that knowledge the next step to take is to decide on a reasonable standard time and enforce it.

While the Committee did not find it practicable, with the other work that it had planned for the year, to make a thorough investigation of the practices of member companies in this respect, it believes that a year should not pass without some progress in this direction. It therefore submits, as an example of the character of accounting that is necessary to lead to the results mentioned, the forms shown in Appendix B of this report which may be used in connection with the overhauling of rolling stock. While these forms show the principal details which the Committee recommends should be presented, they are intended to be suggestive only and can be subdivided further if that should be thought desirable. It will be noted that, in addition to the detail costs mentioned, space is provided for the inclusion of charges for supervision. These charges may be apportioned according to a somewhat arbitrary time basis and are purely for the local supervision conducted under the direction of the head of the subdepartment directly concerned. They have no connection with any general overhead charges.

The work of the Committee has broadened so widely that its attention has been called to other subjects of profitable research. Among these is the Job Order System of Accounting for both Capital and Maintenance Expenditures, which has been in successful use by many companies for several years. We recommend that this subject be taken up as a special study either by a special committee or by the Committee on Engineering Accounting for next year.

BIBLIOGRAPHY OF SCIENTIFIC MANAGEMENT

In the report presented to the 1911 Convention there was compiled and published by the Committee on Engineering Accounting, through the efforts of its Chairman, Mr. P. S. Young, a bibliography of the subject of efficiency and scientific management. At the request of the present Committee Mr. Young has brought this bibliography up to date and it is presented as Appendix C of this report.

INTER-DEPARTMENT CHARGES

The Committee regrets that it has no definite report to make in regard to Inter-Department Charges. The members of the Committee appreciate the importance of this subject, and recommend that it be

assigned to a special subcommittee for investigation next year. This subcommittee should give consideration also to the question of Overhead Charges.

Respectfully submitted,

F. B. LASHER, *Co-Chairman*
J. Z. MURPHY, *Co-Chairman*
C. E. THOMPSON
J. M. JOEL
J. C. COLLINS
H. M. GRAFTON
H. H. ADAMS
J. H. HANNA
JOHN SIBBALD
M. J. FRENCH
Committee on Engineering Accounting

APPENDIX A

EFFICIENCY METHODS OF THE BOSTON ELEVATED RAILWAY CO.

BOSTON ELEVATED RAILWAY CO.

Re: Efficiency Methods.

Mr. PAUL WINSOR, *Chief Engineer Motive Power and Rolling Stock, Boston Elevated Railway Co., Boston Mass.:*

Dear Sir:—Referring to your favor of the 8th inst., requesting information regarding what we have done to promote efficiency and accompanying correspondence of the American Electric Railway Association.

This department continuously during recent years has endeavored to take action that would promote efficiency and we have constantly bettered conditions and reduced costs. We have at no time made hasty or radical changes. Many of our buildings and their equipments are not only not well adapted for our present requirements, but also they are of such construction that we are confronted with serious problems to do our work economically. All our study and action has been directed toward making the best possible use of existing equipment. Without expenditure of money for remodeling buildings or installing equipment, we have endeavored to so plan our work and use our existing shop layout as to secure the largest output of work with the least outlay of new money. We have installed labor saving equipment where practical, such as air or electric hoists.

Our policy has been to plan and schedule our work to the fullest extent possible, to lay out our shops and adjust our labor force to meet this planned schedule, to surround workmen with labor saving utilities, to specialize workmen on various classes of work and most important of all to create conditions attractive to workmen and thus promote their good work and loyalty.

We make constant endeavor to promote co-operation between men and to enthuse all heads and leaders to study for constant improvement and devise saving methods.

We have not followed up any set methods or any one theory or system. We have studied every shop and its conditions as a local factor and endeavored to apply business reasons and "horse sense" to meet particular requirements and conditions.

We have during recent months had one man assigned to study and specialize shop conditions and methods. This man devotes his whole time to this work and reports upon conditions and makes recommendations for changes in any direction that would promote efficiency and reduce costs. As such recommendations are duly approved, this man makes regularly reports of progress.

Towards increasing output and also towards benefiting workmen,

we have to a considerable extent installed piece prices with a result that there is shown a saving in cost to Company as well as material increased earnings to capable workmen.

PIECE PRICES

We now have the major portion of our work done in the Armature Shop, in the Foundry and in the Body Paint Shop on a piece work basis and in addition a considerable amount of the various kinds of work in Machine Shop and other shops.

We endeavor to always fix a price on a unit operation. We do not time work strictly on a stop watch basis, but rather fix a running time on a considerable number of pieces made and allow for a workman's natural movement and necessary time away from the job for personal reasons. But we do endeavor before fixing a price to surround the workman with every utility for quick, convenient and economical handling of materials and tools and with every proper tool, jig or other equipment.

A piece work price once made is not subject to change unless the method of doing the operation is changed.

SHOP CONDITIONS AND UTILITIES

We strive constantly for neat and orderly shops. We keep materials orderly located and in sight and all floor space under machines and benches is kept clear. We supply trucks, carriages, stands and tote boxes for handling materials and locating such convenient to workmen. We have a general labor force to move materials and do not allow mechanics to move materials. We plan to have located at machines and benches, only materials of work in process and we keep other materials in a shop storage section until ready to put such in operation.

We have a workmen's Shop Committee on Shop Improvement, Order and Cleanliness and on Safety Devices. This committee investigates accidents and studies conditions to prevent repetition of such. It also makes reports on Shop Conditions and recommendations for improvements.

PLANNED MOVEMENT

We endeavor to lay out our work in Machine Shop based on our machine tool capacity and to supply men to run the machines. We look to foremen in our shops that are not running on a specific schedule to plan work every day for next day in advance.

We endeavor to put through large quantities at one set up of machine and keep a lead on Stores so as to reduce to a minimum necessity for rush jobs, which are costly, due to upsetting machine tools and disarranging planned movement. In Armature Shop, Truck Shop, Car Body Shop and wherever else possible, we lay out work in sequence

of operations. In Truck Shop, to illustrate, we have a work crew to knock down truck and five other crews to carry on its assembly to completion, every crew doing a certain definite class of work and the trucks are moved forward in order on the tracks from one crew to another.

In our Truck Shop and in our Car Body Shop we schedule the regular work for every season in advance. About four months before beginning the work for the season we receive reports from inspectors on trucks and car bodies that need repairs in shop during coming season. From this list we make a schedule for these shops and at once issue requisitions for needed materials to get such materials into stores and through shops in full season for needs of repair shops.

The schedule as made for Truck Shop and Car Body Shop provides for a definite number for every week during the season, based on estimated time required to put through shop. To specialize workmen we endeavor to bring in all of one type of truck during one period. We also plan schedule so that the withdrawals from car houses will be such as to cause least expense in handling and least interruption to service.

In carrying out this schedule in detail, our Service Car Department through the Yard Master plans ahead for the transportation in and out from car houses in full season to meet this schedule.

We plan movement of wheels in same general manner, commencing with new wheels from manufacturer and through distribution of wheels to and from car houses for service until shipped as scrap.

We plan our general movement of stock service cars in an orderly and economical system, schedule regular stock service from Stores to our twenty-five car houses and eleven power stations, of coal from wharves to power stations and car houses, and of sand and ashes. For special transportation work of service cars, we plan each day's service one day in advance, only to be interrupted by emergency or rush work.

We plan regular methods of handling and moving scrap materials and wheels from shops, etc., until delivery to consignee.

We have a schedule for Car Cleaning at all our car houses. This schedule was carefully worked out after extended study of the work. It covers every detail of cleaning on all types of cars, names methods of work, tools to use, number of men to do work, intervals at which work should be done, time for the job, etc. We attach hereto a copy of this schedule.

We operate a general information office located in our stores department, through which all inquiries are submitted by telephone as to location or delivery of material to various points and through this office, with advance advice secured we endeavor to plan, not only regular work, but special work in so far as *possible and practical as well as Service Car Transportation.*

We believe that we are working in the right direction and have made a reasonably good start towards securing efficiency.

We know that there is very much yet to be done and more can only be accomplished by constant and intelligent study of methods and attendant conditions, applying the best remedy towards improvement that seems available, and by a constant follow up supervision to make sure that changes decided upon are carried into effect and that a saving has been made.

We believe the results have justified our time and efforts and we are convinced that we will continue to show *steady improvement increasingly as a result of what we have already accomplished.*

I trust this report will supply you with the information desired. I do not send list of piece prices we have made because such list would be voluminous and as local conditions have a bearing in fixing a price I doubt whether list of our prices would be of value to any other Company.

Yours very truly,

(Signed) JOHN LINDALL,
Supt. Rolling Stock and Shops.

April 15, 1912.

BOSTON ELEVATED RAILWAY COMPANY—DEPARTMENT ROLLING STOCK AND SHOPS

NOV. 1st, 1911

RULES GOVERNING CAR CLEANING—SURFACE CAR HOUSES

These rules to be followed except in particularly cold or unusual weather conditions when rules may be suspended by direction of Day Car House Foreman.

Note: Time given in *time required* column is a maximum time on 25 ft. box cars. Time allowed on 26½ ft. and 20 ft. cars to be proportional to surface covered.

26½ FT. 25 FT. AND 20 FT. BOX CARS

DAILY CLEANING — EXTERIOR OF CAR

No.		Time Required
1	Mop painted work and side glass (except during stormy weather.)	One man 10 minutes.
2	Clean vestibule glass with damp chamois and towel	One man 10 minutes.
3	Mud splashes to be removed with wash brush and clean water	One man 10 minutes.

DAILY CLEANING — INTERIOR OF CAR

4	SANDING. Sand boxes to be tested by dropping sand on the rail, then fill sand boxes	One man 4 minutes.
5	SWEEPING CAR BODY, VESTIBULE AND STEPS by the following method: Sprinkle lightly steps, platforms and interior floor with disinfectant in solution with water. Turn up cushions. Sweep floor thoroughly towards and onto vestibule	One man 12 minutes.
	Dirt from vestibule and steps to be swept into receptacles. Special attention to be given to dirt around controllers and brake ratchets and behind cab doors. Proper scraper to be used for removing heavy dirt.	

DAILY CLEANING — INTERIOR OF CAR (*continued*)

6	DUSTING. Note: At least two hours time to elapse between sweeping car and dusting same. Cars to be dusted as follows: All of the interior of car body and vestibules and fixtures of same, including window and monitor glass to be dusted with feather duster, except the following, viz.: lamps, hand strap poles, hand straps, window sills, dasher sills, register glass which are to be wiped with dry towel. Care should be taken to see that lamps are not left loose in socket	One man 6 minutes.

Defects in Cars.

Car Cleaners are required to report to Foreman on duty immediately (giving car number in all cases), the following defects, viz.: Sand Boxes failing to work properly, defective light circuits, missing spare lamps, broken glass, missing sign sticks, missing card board signs, defective curtains, broken register or bell cords, exceptional disorder conditions in cars requiring special attention or any other defects that may come to their attention.

PERIODICAL CLEANING — EXTERIOR OF CAR.

No.		Frequency of period.	Time required.
7	WASHING. Wash cars all over below roof using clean water in troughs or pails and wash brushes. In connection with this job the front windows (inside) of vestibule to be washed with brush and water. Vestibule dasher sills to be wiped dry.	After each rain storm.	Two men 15 minutes each.
8	PAINTED WOOD WORK, DASHERS AND EXTERIOR signs to be washed with water and oil soap. Saponified water to be applied to colored work with wash brushes, to white work with suitable scrub brush. All soap to be removed from car body afterwards by thorough rinsing with clean water. Windows to be thoroughly cleaned after this process	Two months	Two men 2 hours each.
9	MONITOR AND VENTILATOR GLASS to be cleaned by wiping with dry towel	Two weeks.	One man 12 minutes.
10	HEADLIGHTS to be cleaned with oil soap, water and waste.	Once a month.	One man 10 minutes.
11	HEADLIGHTS to be painted after thorough cleaning	Twice a year.	One man 10 minutes.

PERIODICAL CLEANING — INTERIOR OF CAR.

		Frequency of period.	Time required.
12	GLASS side window glass, bulkhead glass and vestibule glass to be cleaned with damp chamois	Once a week.	One man 30 minutes.
13	CURTAINS to be thoroughly cleaned with whisk brooms and then wiped with towels	Two weeks.	One man 15 minutes.
14	PLATFORMS AND STEPS loosening all caked dirt with suitable scraper and removing same with whisk broom.	Two weeks.	One man 10 minutes.
15	DASHERS to be washed and scrubbed using corn broom and oil soap and water	Once a month.	One man 15 minutes.
16	DASHERS to be painted with quick drying paint furnished by Bartlett St. Shops, care to be taken that paint is thoroughly dry before car goes out. (Paint will probably require eight hours to dry)	Twice a year.	One man 10 minutes.

PERIODICAL CLEANING — INTERIOR OF CAR (*continued*)

17	WOOD WORK IN CAR BODIES AND VESTIBULE including monitor glass to be cleaned by first wiping with dry towel and then washed with damp sponge. Specially clean water to be used on this job. Heel boards only may be washed with oil soap and water if conditions require it	Once a month.	One man 1 hour.

Semi-Convertible Cars Nos. 1, 2, 3, 4, and 4-A.

DAILY CLEANING — EXTERIOR OF CAR.

No.		Maximum time required.
20	Mop painted work and side glass (except during wet weather)	One man 15 minutes.
21	Clean vestibule glass with damp chamois	One man 15 minutes.
22	Mud splashes to be removed with wash brush and clean water.	One man 10 minutes.

DAILY CLEANING — INTERIOR OF CAR.

23	SANDING. Sand boxes to be tested by dropping sand on rail, then fill sand boxes. Cars to be sanded before being swept.	One man 4 minutes.
	SWEEPING CAR BODY, VESTIBULE AND STEPS by the following method:— Sprinkle lightly, steps, platforms and interior floor with disinfectant in solution with water. Using a suitable broom, sweep side sills and floor under transverse seats, sweeping all dirt onto centre matting, sweep centre matting and floor space not previously covered towards and onto vestibule floor	One man 20 minutes.
	Dirt from vestibules and steps to be swept into receptacles. Special attention to be given to removing dirt around air brake pipes, hand brake ratchets and behind cab doors. Proper scraper to be used for removing heavy dirt.	
25	DUSTING. Note: At least two hours time to elapse between sweeping car and dusting same. Cars to be dusted as follows:— All of the interior of the car body, vestibule and fixtures of same, including window and monitor glass to be dusted with feather duster except the following:— Lamps, hand strap rails, window sills, dasher sill, seat arms and register glass which are to be wiped down with dry towel. Care should be taken to see that lamps are not left loose in socket	One man 10 minutes.

Defects in Cars.

Car Cleaners are required to report to Foreman on duty immediately (giving car number in all cases), the following defects, viz.: Sand boxes failing to work properly, defective light circuits, missing spare lamps, broken glass, defective curtains, defective doors, broken register or bell cords, exceptional disorder conditions requiring special attention or any other defects that may come to their attention.

PERIODICAL CLEANING — EXTERIOR OF CAR — SEMI-CONVERTIBLE.

		Frequency of period.	Maximum time required.
26	WASHING. Wash cars all over below roof using clean water in troughs or pails and wash brushes. In connection with this job the front windows (inside) of vestibule to be washed with brush and water. Vestibule sill to be wiped dry	After each rain storm.	Two men 20 minutes each.
27	PAINTED WOOD WORK, DASHERS AND EXTERIOR SIGNS to be washed with water and oil soap. Saponified water to be applied to colored work with wash brushes, to white work with scrub brush. All soap to be removed from car body afterwards by thorough rinsing with clean water. Windows to be thoroughly cleaned after this process, using pumice stone if necessary to remove the rust accumulation	Every two months.	Two men 2½ hours each.

No.		Frequency of period.	Maximum time required.
28	MONITOR GLASS to be cleaned by first wiping with dry towel then cleaning with damp chamois. Includes interior and monitor glass, No. 1, 2, 3 cars	Every two weeks.	One man 15 minutes.
29	HEADLIGHTS to be cleaned with oil soap, water and waste.	Once a month.	One man 10 minutes.

PERIODICAL CLEANING — INTERIOR OF CAR — SEMI CONVERTIBLE.

No.		Frequency of period.	Maximum time required.
30	GLASS. Side glass, air door glass and vestibule glass to be cleaned with damp chamois	Once a week.	One man 40 minutes.
31	CURTAINS. To be thoroughly cleaned with whisk broom and then wiped with dry towel	Two weeks.	One man 20 minutes.
32	PLATFORM AND STEPS. Removing all caked dirt by first loosening dirt with suitable scraper and removing same with whisk broom	Two weeks.	One man 10 minutes.
33	DASHER WASHING. To be washed and scrubbed, using corn broom, oil soap and water	Once a month.	One man 30 minutes.
34	DASHER PAINTING. To be painted with quick drying paint furnished by Bartlett St. Shops. Care to be taken that paint is thoroughly dry before car goes out. (Paint will probably require 8 hours to dry)	Twice a year.	One man 10 minutes.
35	WOOD WORK AND SIDE SILLS IN CAR BODY AND VESTIBULES also monitor glass to be cleaned by first wiping with dry towel and then washed with damp sponge, specially clean water to be used on this job	Once a month.	One man 2 hours.

Approved:

(Signed) JOHN LINDALL,
Supt. Rolling Stock and Shops.

DUTIES OF NIGHT FOREMAN CAR CLEANERS

RESPONSIBILITY OF NIGHT FOREMAN— Night Foremen are responsible to Day Foreman of their respective car houses for a proper performance of their duties.

The Night Foreman has charge of the Car House and its contents and is Chief of Night organized fire fighting force. During the absence of Night Foreman from Car House between the hours of 6 P. M. and 7 A. M. a competent employee designated by the Day Car House Foreman will be responsible for Night Foreman's duties.

DUTIES OF NIGHT FOREMAN — To supervise the following work and to work with the men to such an extent as the Day Foreman may designate, taking into consideration proper time required for supervision, viz.:

Car Cleaning as laid out by Day Foreman to be performed according to rules.

Lining up cars for routes.

Signing cars for morning work.

To provide men to work on sand cars.

Cleaning lobbies and offices.

To see that trolleys are kept off the wire, except when men are working on cars.

To see that heater and motor switches on cars are open.

Poster work.

To provide men for wrecking calls when necessary.

To see that boilermen perform their duties.

To provide men on request to call snow crews.

To furnish Day Foreman with a daily record of all work done, also record of unusual events and defects found in cars.

APPENDIX B

SUGGESTED FORMS FOR USE IN COST ACCOUNTING

MOTOR AND TRUCK SHOP REPAIR CARD

Car No..... Type..... Division.....

Date started.....19..... Foreman.....

MOTOR AND ELECTRIC EQUIPMENT

	Date	Hours	Names	Amount
Overhauling motors				
" "				
Overhauling cables and motor wiring				
Controllers, circuit breakers and resistance				
Heater, light and bell wiring				

Total labor.....

Supervision charges.....

TRUCKS AND MISCELLANEOUS

	Date	Hours	Names	Amount
Overhauling trucks				
" "				
Hand brakes				
Air brakes				
Fenders				
Shifting				
Jacking car				
Miscellaneous				

Total labor.....

Supervision charges.....

SUMMARY

Motor and electrical labor.....

Truck and miscellaneous labor.....

Total.....

REMARKS

.....

.....

.....

Date completed.....

O. K.....Foreman.

CAR REPAIR CARD

Car No..... Type..... Division.....

Date started.....19.....

CARPENTER SHOP WORK

	Date	Hours	Names	Amount
Stripping				
Repairing car body				
" "				
" "				
" "				
" "				
" Doors				
" Sash				
" Seats				
Repairing vestibules				
Repairing bonnets				
Cleaning seats				
Trimming				

Total carpenter shop labor.....

Supervision charges.....

Date completed.....

O. K.....Foreman.

CAR REPAIR CARD

Car No..... Type..... Division.....
Date started.....19.....

PAINT SHOP WORK

Outside of car

	Date	Hours	Names	Amount
Scrubbing				
Removing paint				
Preparation coat				
Putty and plaster				
First coat color				
Second coat color				
Lettering and striping				
First coat varnish				
Second coat varnish				
Third coat varnish				
Roof dome and ventilators				
Trucks and wheelguards				
Floors, gates and bumpers				

Inside of car

Touching up				
First coat rubbing varnish				
Second coat rubbing varnish				
Coat finishing varnish				
Cleaning all glass				
Cleaning and dressing curtains				
Inspection and final touch up				

Total paint shop labor.....
Supervision charges.....

REMARKS

.....

.....

Date completed.....

O. K.....Foreman.

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Discussion of Report of the Joint Committee on Engineering Accounting

PRESIDENT ACKERMAN:—Gentlemen, the report of this Committee is now before you for discussion.

MR. BARNES:— I think the subjects covered in this report merit considerable discussion. I regret that I have not had more opportunity to study it in detail so as to take up a number of points, but there is one point mentioned on page 477, that seems to me to be of the utmost importance, and that is the matter of keeping full detail costs of shop work and other departmental expenses. The Committee speaks of the benefit accruing to the management from knowing the exact expenditures on the different classes of work. It is difficult to estimate just how valuable this information may be. It is certainly of very great value, not only to the management, but of still more, in my judgment, to the departmental head. In our experience, we have found that by keeping careful detailed costs of separate charges, we have been able to try out several methods and reach a very accur-

ate comparison as to the efficiency of each; and while we have not taken up the work that is generally described as "efficiency engineering," we have, nevertheless, been able to apply some of the fundamental principles of that work and obtained results, through them, that we would not have been able to obtain without detailed costs, or even without the full co-operation of our auditing department. This point cannot be over-emphasized.

Mr. French:— Regarding engineering accounting, as applied to the way department, it seems to me, in order to make our work efficient, the way department must have more intimate relations with the auditing department in order to have our records correct. I think, as a rule, the timekeepers and foremen of our department are responsible for the accounting of the actual cost of the work performed. As a rule, the duty of reporting the different classes of work performed is delegated to a foreman. It seems to me that the time has come when the auditing department must take this work over in order to give us good results. The job order system originates with them, and it is a complex system. They are thoroughly familiar with it; they have taken the distribution of accounts out of the hands of the way engineer, and his views do not always count for very much. I should like to hear from some of the companies, who have put this work into the auditing department, as to what results they have obtained, and also from the way engineers under whose direction this work is being done as to whether or not they are satisfied with the way the auditing department handles the work.

Mr. Clark:— On January 1st of this year, the timekeepers were turned over to the auditor. I had always handled them and had all sorts of complaints from the auditor, saying that they were not keeping their accounts straight. So I thought I would let him have the timekeepers, and now he has them. Since then the auditor's assistants are continually running to my office and asking whether so and so is right, and, of course, I have to make a diagnosis of the accounts and tell them "Yes" or "No." The work orders originate in the engineer's department. We write the work order and instruct

the timekeepers that such and such work must be charged to maintenance and the other to capital, or it may be a division of expenditures, like grade crossing work, where the franchise ordinance says "The Cleveland Railway Company must bear the expense of all the detour of the cars, the tearing up of tracks and pavements." The replacing of tracks and pavements is borne by the city and the steam railway company in the proportion of 35 per cent. by the city and 65 per cent. by the railway company. It is pretty hard work for the timekeeper to see which is which, and, of course, it is up to the auditors, for the timekeepers are under them, if they do not report the work correctly after they have had their instructions written out. I find however, that by putting the timekeepers under the auditor, it relieves the auditor of a good deal of extra work.

MR. NICHOLSON:—I will say in connection with the remarks of the previous gentleman, that our company experienced considerable difficulty in obtaining an accurate distribution of the track time. At the present time our timekeeper visits all the work daily and makes the distribution of the time on the work, reporting to the accounting department. His daily time sheet is turned into the accounting department and a duplicate copy is sent to our engineer of maintenance of way; so that if there are any inaccuracies he can check them. We find this system works out very well.

MR. EVANS:—This is a subject I am most interested in, for on last Friday we were asked to prepare a paper on this subject to be read before the Canadian Street Railway Association at London, Ontario. In keeping the accounts of construction costs, the timekeeping pertaining to same is handled by our accounting department, but their distribution is not as extensive as we desire, therefore, we have our men distribute the cost of each item as the work is performed. Formerly we had, with all gangs, a tool box attendant who was as a rule an aged employee; but we have now done away with these men in this capacity and hired young college men and increased their pay from 17.5 to 20 cents per hour. It is the duty of these men to watch all tools and material re-

ceived on the job, as well as to compute the quantity and unit costs for each item of the work done. The system works so well, that we know what the unit costs are on each job running over the system. I said it works perfectly, but this is not exactly so because some of the reports are delayed in coming to the head office for some reason, which you see often delays the summarizing of the reports.

In my experience with electric railways, I have found but two companies out of twelve which are advised as to their unit costs promptly (daily or weekly). Now, in addition to the daily unit costs, one should be advised daily of the total unit costs because the daily unit costs may be running under or over the estimated unit costs, on account of the engineers under — or over — estimating quantities of work to be performed. One must keep well in mind the probable final costs of each item as a comparison to the estimated costs. The simplest method of doing this, according to the speaker's idea, is by having the daily reports always on hand.

In my opinion, maintenance of way engineers should give more attention to daily unit costs, which from my own experience has not been done in the past, or at any rate, they have not kept them in the form of a report so that they could be referred to daily.

I would invite you to read the records of the proceedings (as to unit daily construction costs) of the Canadian Street Railway Association, held in London, Ontario, October 4th and 5th after they are published, and I beg to state that they are the beginning of a long discussion which I personally intend to follow up.

Mr. Wilson :— It has been the custom in our company to have the timekeepers, who have anything to do with computing expenses of maintenance of way work, under the control of the auditing department, but so far as the division of the work is concerned, they are under the direction of the engineer of maintenance of way. We obtain in the maintenance of way department, constantly, accurate figures as to the unit costs, but we do not receive them quite so promptly as we would like. In fact, there has been a good deal of delay, so

in order to know how things are running, it has been our practice to have a cost clerk or a man who looks after the expenses, as the work is done, so that while the work is in progress we may know what the unit costs are. After the work is completed and the job is finished, the auditing department sends the track department complete information regarding the work, according to its records. This seems to work out very well. As Mr. Adams suggested, a young man who is pretty swift at figures may be employed with each crew, but unless the crew is large you will unduly increase the clerical expenses.

We find the best practice is to employ steadily a cost clerk familiar with timekeeping and also with our work. His services are worth more with experience and we obtain better results.

It is a relief to the maintenance of way department not to have the timekeeping directly under the charge of the maintenance of way engineer. I believe it can be handled to better advantage by the auditing department.

The engineer should decide as to the classification or headings under which the costs of each construction job are to be kept for the information of his office; these items later to be charged by the auditing department in accordance with its standard classification.

Mr. Adams:— Mr. Wilson just touched on a question which is a vital one, that is, the question of additional clerical force. It has been my experience, that comparatively little additional clerical cost is necessary to keep detailed cost accounting, in such shape as to be of great value in the reduction of the total cost. The amount of expense for clerical labor is insignificant as compared with the total saving. By a good system of cost accounting you can study the individual operations and make reductions on them, to such an extent that it wipes out any question of clerical expense.

Mr. MacRae:— This question of keeping time is one in which I have always been very much interested. I am in favor of keeping all time accounts and distributions in the auditor's office. At the time when I was the auditor for only

The Metropolitan West Side Elevated Railway, every man in the employ of the company made out a time slip, and that time slip came to my office; was recorded in my office; distributed in my office, and the payrolls made up in my office. At the end of the month I gave each department head a complete statement of the operating expenses of his department. When I became the auditor of the Northwestern and the South Side Roads, all of the department heads requested that the same system be adopted in the case of the Northwestern and South Side Roads. I made no motion in that direction myself, but all of the department heads wished me, as auditor, to take over into my office the work of keeping all the time. That shows, apparently, from our experience at that time, that the department heads were satisfied that the work should be done in the auditor's office. In my judgment, that is the place where the work should be done. When the work is done by a department head — this is not intended as a reflection on the engineers of maintenance of way — my experience is that where the work is done by the department heads the accounts are padded. I have known cases on several lines where there was a distribution of expenses through a large number of accounts, to cover up certain expenses which were excessive.

When the time slips come to the auditor's office, and where the work is done by the auditor, or some disinterested official, the president of the company and others interested in expenses are given figures that are reliable. I have no interest in making false reports. All I want to know are the exact facts regarding operation and to give those to the president, no matter who is affected. If the head of the department makes a good showing at the end of the month he gets credit for it. On the other hand, if the report is bad, he is asked to explain. I have always been very insistent in having all the timekeeping done in the auditor's office. Everything, so far as the accounting end is concerned, is done in the auditor's office. The auditor has absolute authority over all matters of accounting. This is our practice on the elevated railroads in Chicago.

There is one other matter in which I am interested, and

that is the question of distribution of power. On the elevated roads we make a separate division for power accounts and it is a distribution which I would personally like to have the Accountants' Association adopt, but I do not think they will. When the electric railroads started operation, they followed to some extent the steam railroad practice — "Maintenance of Way," "Maintenance of Equipment" and "Conducting Transportation." The electric railroads are on a somewhat different basis from the steam roads. We have a different classification in our companies. We have: "Maintenance of Way," "Maintenance of Car Equipment," "Maintenance and Operation of Power Plant Equipment," and "Conducting Transportation." Our power plant has an absolutely separate and distinct classification by itself. We do that because we do not wish to confuse, in our car equipment, the cost of maintenance of the electrical equipment. That is, we are keeping all of our accounts by department heads. We have an engineer of maintenance carrying an account "Maintenance of Way." We have a master mechanic carrying an account "Maintenance of Car Equipment." We have an engineer in charge of power house carrying an account "Maintenance and Operation of Power Plant Equipment." At the end of any given period we know exactly what each department is costing.

Mr. Boylan :— Our system is very similar to that outlined by Mr. MacRae. I might say, in connection with the keeping of costs, that the timekeepers of the track department are generally under the direction of the accounting department and maintenance of way department. The job orders are filed in the office of the engineer of maintenance of way. They are forwarded in the usual manner to the manager's office, and finally are filed with our office. We forward monthly to the engineer of maintenance of way a detailed statement of the cost of all jobs.

The same procedure is followed for construction work. In addition to that we go one step further and have what we call a "permanent job order" for every building, every street, and all our overhead work. These charges are posted monthly to

the permanent job order and the engineer of maintenance of way and the manager can see at a glance what it is costing to maintain a certain piece of track in a certain locality. The same thing applies to buildings and lines. We have had that system in force seven or eight years and find it very valuable, particularly when the question comes up as to when we renewed a certain piece of track.

In the case of repairs to cars the job order is issued by the mechanical department practically in the same manner as I have outlined, and we have a record of all expenses on each job order. When the job is completed the final report is sent showing the cost of that particular job. In other words, we keep our heads of departments informed weekly of the various charges and maintenance of construction accounts, and also we send them a complete detail monthly. We also have a job order in connection with the manufacturing material and supplies for the storekeeper which we carry out in the same manner.

MR. GLOVER:—As to the matter of separating power plant equipment from the rolling stock equipment, I think Mr. MacRae's suggestion is provided for in the report of this Committee. It separates the cost of the maintenance of the power plant from the maintenance of rolling stock, and also separates the operation of the power plant from conducting transportation. That is provided for, and I hope the Committee on a Standard Classification of Accounts will follow the suggestion of this Committee.

MR. MACRAE:— The classification does not make that clear. It is true that the classification in the car equipment provides as to the maintenance of car equipment and maintenance of electrical equipment. It is also true that in transportation, the operation of the power plant is separated from the operation of the transportation department, but our classifications are absolutely separate and distinct, that is "Maintenance" and "Operation of power plant equipment."

MR. BARNES:—Another point occurs to me in connection with the question of the subdivision, as between power plant

and rolling stock equipment. It might also be well to make a similar subdivision in the way account, between the electric line accounts and the supervision of the electric line accounts. Such a classification might be of marked value.

A word in connection with Mr. Boylan's remarks — the job order system, which he outlined, is very close to the practice of the companies with which I am connected, and we find it of the greatest convenience, for the issuance of the job order is under the control of the heads of departments. Now, if the head of the department feels he is not obtaining as much detail as he ought to have, or as much as he would like to have, or if he wants to know about some particular thing, all that is necessary for him to do is to issue enough job orders to cover the various points he wishes to be informed about. In that way he will get full and complete information from the auditor.

MR. SIBBALD:— This scheme of the Public Service Railway Company, calling attention of the motorman to saving power by coasting and proper operation of the controller, is so inexpensive that almost any company could try the system, and we did. While we had no way of measuring the benefits received, simple observation indicated that we secured a smoother operation of the cars. There was an effort on the part of the motorman to make excellent stops, and we are very much in favor of the idea. It costs but very little and impresses the men with the importance of saving the power.

PRESIDENT ACKERMAN:— Is there any further discussion on this subject? If not, what disposition will you make of this report?

MR. GLOVER:— I move that the report of the Committee be received and approved.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— We have with us Mr. L. T. Hixson, First Vice-president of the Accountants' Association, and I will ask him to take the chair.

(Mr. L. T. Hixson now in the chair.)

CHAIRMAN HIXON:— The next report on the program is is that of the Committee on Life of Railway Physical Property,

which will be presented by Mr. Martin Schreiber. I understand that there are no printed copies of this report.

MR. SCHREIBER:— Mr. President and members of the Engineering and Accountants' Associations: In the absence of Mr. Wallis, who is also Co-Chairman of the Committee, I will be glad to submit the report. I am sorry that the advance papers covering this important topic were not printed in time for distribution, but as the recommendations and conclusions are brief I will read the report.

REPORT OF COMMITTEE ON LIFE OF RAILWAY PHYSICAL PROPERTY

To the American Electric Railway Engineering and the American Electric Railway Accountants' Associations:

GENTLEMEN.—Your Committee was instructed by the Executive Committee of the two Associations to give consideration to and report on the life of railway physical property.

The subject before us originated in the Accountants' Association at the request of officers of the American Association and a committee report may be found in the 1911 proceedings of the American Electric Railway Accountants' Association, pages 200–203. For reasons stated in that report, the Engineering Association was joined and two meetings have been held by the Joint Committee at the Association rooms in New York, the first on January 25, 1912, and the second on July 11, 1912. In addition to the meetings, much interim work has been done by the members of the committee and others who have been called upon to assist them, notably in securing data to file for the use of members in the Association rooms. Attention is especially called to this branch of the work and members interested in the subject are urged to make use of the data so collected and arranged.

At the meeting in January, the scope of our work was thoroughly discussed and serious consideration was given to the possibility of ultimately providing comparative figures for the life of various elements of railway property with a bibliography and other statistics. From the beginning was recognized the difficulty of formulating any definite figures which could apply generally, because of the variable features involved and the differing conditions at different locations. It was also realized that in any search for original data materially different figures would be received even if all the conditions were carefully defined. Therefore, no attempt has been made to strike any general averages either as to authorities quoted or from any data collected from members concerning life of railway material. In the opinion of your Committee, it would be unwise in the present state of the

industry to attempt to do so. Information and figures on this subject can be obtained and recorded only as a guide for study and not as a rule for action.

Your Committee therefore outlined its work to include the gathering together and rendering available for use of the Association membership facts and figures relating to the subject committed to it. Not only do we deem it important to gather such information as may have been published from time to time upon this subject, but also as possibly a more valuable branch of the work to secure from authoritative and experienced sources original data which has not been made available for general use.

Investigation of existing tables concerning the life of railway physical property compiled by different authorities show a lack of availability for comparison because the tables are not consistent in the consideration of similar items.

It was the opinion of your Committee, therefore, that a certain standard classification should be formulated as a guide to investigation upon this subject, and your Committee therefore adopted as standard the following classification for consideration of the life of railway physical property item by item.

Buildings and Structures

1. Buildings (frame).
2. Buildings (brick), stone and concrete foundations and walls; wood roofs and floors.
3. Buildings (brick), stone and concrete foundations and walls; including floors and roof of concrete or fire-proof construction.
4. Dam (concrete, earth).
5. Dam (wood, earth).
6. Dam (earth).
7. Flume (masonry).
8. Flume (wood).
9. Flume (steel).
10. Conduit for wire (terra cotta).
11. Conduit for wire (creosoted wood).
12. Bridge for trestle (steel with concrete foundations; P. R. W.).
13. Bridge (steel with concrete foundations; wood roadway).
14. Bridge (steel with concrete foundations; roadway with concrete foundation and permanent paving).
15. Trestle (Yellow pine piles and timber, untreated).
16. Culvert (masonry).
17. Bridge (concrete).

Equipment

1. Car bodies.
2. Control equipment.

3. Air brake equipment.
4. Motors.
5. Trucks.
6. Miscellaneous shop tools.

Power Distribution

1. Trolley wire.
2. Third rail.
3. Feeder (W. P. insulated).
4. Cable (conduit lead covered).
5. Poles (iron).
6. Poles (wood).
7. Tower (steel).
8. Line material.
9. Signals.
10. Automobile truck.
11. Horse vehicles.
12. Horses.

Power Generation

1. Water wheel.
2. Engine (steam).
3. Turbines.
4. Boilers.
5. Condensing system.
6. Piping system.
7. Producer (gas).
8. Engine (gas).
9. Generator.
10. Converters.
11. Transformers.
12. Switch board apparatus.
13. Storage battery.
14. Coal handling machinery.

Way Matters

Track in paved streets assuming 7½ minutes headway with 5-minute headway in rush hours, 30-ton double-truck cars.

1. Ballast.
2. Rail.
3. Joints.
4. Ties (untreated).
5. Bonds.
6. Hardened center special work.

Open track, same headway and weight of cars as above.

7. Rail.

8. Ties (untreated).
9. Joints.
10. Bonds.
11. Special work.
12. Miscellaneous track machinery.

What is the life of each of the above if earth ballast existed?
Closed track:

2.
3.
4.
5.
6.

Open track:

2.
3.
4.
5.
6.

What is the relative life of the following in track, assuming same traffic and granite block-100?

1. Granite block-100?
2. Trap rock block.
3. Medina sandstone.
4. Brick.
5. Asphalt block.
6. Wood block.
7. Amiesite.
8. Bitulithic.
9. Asphalt.
10. Macadam.

Conclusions and Recommendations

1. Your committee has collected valuable and interesting data which is filed in the Association office for the use of members and some of the more general of which is included with this report.

2. It is the opinion of your Committee, for reasons hereinbefore stated, that it will not be practicable to compile any standard table that is generally applicable to the life of railway physical property at all places and under all conditions. Too many factors must be taken into consideration, notably the degree of maintenance, preservation, obsolescence, and depreciation. All of these are certain to vary more or less in each individual case and should be separately investigated.

3. The custom of compiling figures to represent life of property in a particular case, when such figures are primarily based on investigation

of other properties in different locations and under varying conditions, is unscientific and often unfair.

4. Comparisons can be fairly made only on a common ground. Therefore, we recommend that, in order to insure uniformity and a reasonable degree of comparability, all investigation and data bearing upon the life of property be based on a standard classification as cited in this report. We urgently recommend that members make conscientious and painstaking study of the life of various elements of railway physical property and that the lines herein laid down be followed. By such uniformity, and in this way alone, much valuable information may be elicited which will be of great value to the industry.

5. The Committee has assembled from numerous compilations an extensive bibliography on the subject of life of railway physical property, including very generally the valuable literature on the subject. This bibliography is submitted with this report as Appendix (A). It is recommended for your attention in case information on the subject is desired.

6. The Committee has also secured from Ford, Bacon & Davis a comprehensive table, the result of extensive research, giving in tabulated form very nearly all the published figures used in considering depreciation of railway property. This is included in the report as Appendix (B), and it brings together from some fifty sources figures used by eminent authorities in putting into figures their conclusions upon this subject.

7. It is our opinion that the investigation of this subject before the committee should be continued so that all information may be properly compiled and kept up to date for ready reference at any time.

8. Your Committee invites comment as to any phase of this report and will gladly welcome any suggestions, which will be given careful consideration. We shall also be glad to receive any data bearing upon the subject which may find proper place in the Association's files.

Respectfully submitted,

R. N. Wallis, *Co-Chairman,*
Martin Schreiber, *Co-Chairman,*
A. R. Patterson,
H. E. Weeks,
John Lindall,
F. B. Batchelder,

Joint Committee on Life of Railway Physical Property.

APPENDIX A

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Note:

This bibliography does not include references to the Proceeding and Reports of a number of Associations and Commissions which contain valuable data on this subject. For the information of the reader a partial list of these bodies is appended hereto: American Electric Railway Association, American Electric Railway Accountants' Association, American Electric Railway Engineering Association, American Water Works Association, American Institute of Mechanical Engineers, American Street and Interurban Railway Association, Chicago Traction Valuation Commission, Interstate Commerce Commission, Massachusetts Railroad Commission, Massachusetts Electric Lighting Commission, National Electric Light Association, New York Public Service Commission, Wisconsin Railroad Commission.

Detailed references to these reports cannot be provided at this time but will be developed later.

APPENDIX B

STATISTICAL BRIEF

Tabulating Rates and Life Considered by Various Authorities

This is a compilation of various estimates of rates of depreciation of engineering structures, as published in various books and periodicals.

REFERENCES:

The following "List of References" serves the purpose of a bibliography, and at the same time contains necessary information as to the source of the estimates embodied in the subsequent table, the derivation being indicated in each case by an appropriate reference number.

TABULATION:

"The Table of Depreciation Estimates" embodies material taken from the "References" as indicated by the number in the second column. The rate of depreciation shown in the fourth column is in every case apparently figured by the straight line method; that is, the percent depreciation is the reciprocal of the assumed years of life, except that in the case of Reference No. 4 it is obviously figured by the sinking fund method.

The compiler has not converted "percent depreciation" into "years of life," or vice versa, but has in each case used the figure appearing in the original.

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TABLE OF DEPRECIATION ESTIMATES

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Aerial lines	1	St. Louis Public Service Commission	5	....	....
Air brakes	1	Wisconsin Railroad Commission	5	....	....
Air compressors	1	Traction Valuation Com., Chicago	4–5	....	....
Arc lamps	1	Wisconsin Railroad Commission	6.67	....	....
	1	Arbitrators, Atlanta, Ga	15	....	....
	1	St. Louis Public Service Commission	8	....	....
	6	Foster (including spare equipment)	10–15	....	....
	20	Sir Henry Preece, London	12	....	....
Belting	1	Wisconsin Railroad Commission	5	....	....
	6	Foster power plant belts	20–25	....	....
Boilers	1	Traction Valuation Com., Chicago	3.5–4	....	....
	1	B. J. Arnold, Coney Island and Brooklyn	10	....	....
	1	Water tube. Henry Floy	5	....	....
	1	Water tube. Wisconsin Railroad Com.	5	....	....
	1	Fire tube. Wisconsin Railroad Com.	3.33–6.67	....	....
	1	Fire tube. Arbitrators, Atlanta	10	....	....
	10	Pence. Milwaukee Three Cent Fare Case	8.5–6.67	....	....
	3	Marwick Mitchell & Co	4.5	....	....
	18	Chicago Union Traction	6.6	....	....
	11	Milwaukee Electric Railway and Light	7.5	....	....
	12	Arnold. Chicago Appraisals	2.5	....	....
	13	Chicago Traction Company	3.5–10	....	....
		Chicago United Traction	6.6	....	....
	13	Milwaukee Electric Ry. & Light Co.	7.5	....	....
	13	Wisconsin Railroad Commission	6.6–8.5	....	....
	13	Average English and Scotch Practice	5	....	....
	13	Phillip Dawson	8–10	....	....
	13	Stone & Webster	5	....	....
	13	Professor Gebbardt	4–6.6	....	....
	13	Water tube. Light service	4–6.6	....	....
	13	Water tube. Heavy service	5–8.3	....	....
	13	Fire tube. Light service	5–6.6	....	....
	13	Fire tube. Heavy service	6.6–10	....	....
	6	Fire tube. Foster	.....	10–15	....
	6	Water tube. Foster	.....	20–30	....
	19	Boilers and settings, power-house	8–10	....	....
	20	Water tube. Sir Henry Preece	.....	25	5
	21	Dawson's pocket book	.....	15–30	....
	22	Railway plant boilers	.....	20	....
	24	Standard Handbook for Electric Engrs.	4–5	....	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Boilers	29	Troutwine's Hand Book		20	
	37	R. W. Prosser. Gas plants		15	10
	40	Hammond-English. Electric light plant		20	
	41	Hill-Public Service Appraisals	5–7		
	42	With good water and good care		20	
	45	Cardiff. Municipal city estimate	5		
Bonds (rail)	1	Traction Valuation Commission, Chicago	5		
	10	Electric Traction Weekly	7 12		
Breeching	1	Traction Valuation Commission, Chicago	3 5 10		
	12	Steel. Arnold, Chicago	10		
Bridges	41	Trestle bridges. N. S. Hill	15–20		
	41	Iron bridges. N. S. Hill	5		
Buildings	1	Brick. Traction Val. Com., Chicago	1.5		
	1	Brick. E. G. Connette	2		
	1	Brick. Wisconsin Railroad Commission	2–4		
	1	Frame. Arbitrators, Atlanta	2		
	1	Frame. St. Louis Public Service Com.	2		
	3	Railway. Marwick Mitchell & Co	2.5		
	14	Fireproof data		25 50	25
	14	Mill construction		25	20
	5	Brick. Occupied by owner	1–1.25		
	5	Brick. Occupied by tenant	1.25–1.5		
	5	Frame. Occupied by owner	2–2.5		
	5	Frame. Occupied by tenant	2.5–3		
	6	First-class stone or brick. Wisc. Com.		75	
	6	Second-class shops, car barns and power station, Wisconsin Commission		50	
	6	Brick gas retort houses. Wisconsin Com.		30	
	6	Frame dwellings. Wisconsin Com		35	
	6	Frame stables and coal sheds. Wisc. Com		20–25	
	16	Masonry buildings. Metcalf		40–50	
	16	Wooden buildings. Metcalf		20–50	
	18	Cable power plant. Stone & Webster		30	
	18	Electric power plant. Stone & Webster		50	
	18	Cable power plant. Chicago United Trac.		15–20	
	18	Electric power plant. Chicago Un. Trac.		20	
	18	Other than power-house		50	
	21	Dawson's pocket book		50	
	23	Tri-City Railway		50	
	24	Fireproof. Standard Handbook	2 3		
	24	Frame. Standard Handbook	5–8		
	25	Substation. Hutchinson		25	
	29	Permanent water-works. Troutwine		100	
	37	Gas plant. Prosser		40	
	38	British Columbia Electric Railway	1		
	39	Kansas City Western Railway	2.5		
	40	Land and buildings. Hammond		60	
	41	Wooden. N. S. Hill	5		
	41	Brick. N. S. Hill	2		
	44	Buildings and fixtures. Dalrymple	3		
	45	Cardiff Electric Tramway and Light	2.5		
	47	Power plant	4	25	
Cables	1	Underground high tension. Floy	5		
	1	Aerial lead covered. Wisc. R. R. Com.	6.67		
	1	Underground lead cov'd. Wisc.R.R.Com.	4		

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Cables	3	Feeder collar overhead	3	....	....
	3	Feeder collar leaded in ducts	4	....	....
	4	Telephone, main	3.72	20	....
	4	Telephone, subsidiary	5.38	15	....
	4	Telephone, aerial	5.38	15	....
	14	Telephone, aerial exchange	.....	12–15	30
	14	Telephone, in buildings	.....	10	30
	14	Telephone, exchange main	.....	20–25	40
	14	Telephone, exchange subsidiary	.....	13–20	40
	14	Telephone, toll	.....	30	40
	14	Telephone, submarine	.....	10	0
	13	Wires and cables. Chicago Trac. Com.	2	....	....
	13	Wires and cables. Chicago Union Trac.	6.6	....	....
	13	Wires and cables. M. E. R. & L. Co.	5	....	....
	13	Wires and cables. Wisconsin R. R. Com.	2	....	....
	13	Wires and cables. Average English Prac.	5	....	....
	13	Wires and cables. Average Scotch	3	....	....
	13	Wires and cables. Philip Dawson	3–5	....	....
	13	Wires and cables. Stone & Webster	5	....	....
	13	Wires and cables. Prof. Gebbardt	5	....	....
	15	Telephone, main	3.5	....	....
	15	Telephone, subsidiary	5	....	....
	15	Telephone, aerial	6	....	....
	10	Feeders and cables, railway. Pence	4	....	....
	11	Feeders and cables. railway. Milw. Co.	5	....	....
	12	Feeders and cables, railway. Arnold	1.5	....	....
	6	Aerial lead covered, power	.....	10–15	....
	6	In ducts lead covered, power	.....	20–25	....
	6	Aerial lead covered, telephone	.....	12	....
	6	In ducts lead covered, telephone	.....	20	....
	20	Armored, power. A. D. Williams	.....	35	15
	21	Power. Dawson's pocket book	.....	10–20	....
	24	Lead covered, Power. St'd. Handbook.	2–20	....	....
	25	Cables and heavy wiring in power-house.	.....	10	....
	45	Conduits and cables, Cardiff	3	....	....
Coal and ash handling machinery.	1	Traction Valuation Com., Chicago	7	....	....
	1	Henry Floy. N. Y. P. S. C.	5	....	....
	1	Wisconsin Railroad Commission	10	....	....
	10	Milwaukee Three Cent Fare Case. Pence.	20	....	....
	11	Milwaukee Electric Railway and Lt. Co.	10	....	....
	12	Arnold	7	....	....
	6	Foster	.....	10	....
	22	Atkinson	.....	10	....
	40	Hammond	.....	10	....
	10	Pence. Milwaukee Case	20	....	....
	11	Milwaukee Electric Railway and Lt. Co.	10	....	....
	12	Arnold	7	....	....
	48	Chicago Union Traction Co	6.66	....	....
	49	Stone & Webster	5	....	....
Condensors	1	Traction Valuation Com., Chicago	4	....	....
	1	Arnold. N. Y. P. S. C.	5	....	....
	1	Henry Floy. N. Y. P. S. C.	5	....	....
	1	Wisconsin Railroad Commission	5	....	....
	1	Arbitrators. Atlanta	10	....	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Condensors	1	St. Louis Public Service Commission	6.67	....	....
	6	Power plant. Foster	.....	20–30	....
	6	Gas scrubbers and condensors	.....	30	....
	23	Tri-City Railway Co	.....	15	....
	37	Gas: condensors, scrubbers and purifiers.	.....	30	20
	41	Power plant. N. S. Hill	7–10	....	....
Conduit	1	Henry Floy. N. Y. Public Service Com.	1	....	....
	1	Wisconsin Railroad Commission	2	....	....
	1	St. Louis Public Service Commission	2	....	....
	3	Marwick Mitchell & Co	2	....	....
	4	Main, clay in concrete, telephone	.....	50	0
	4	Main, fibre in concrete, telephone	.....	20	0
	4	Subsidiary, telephone	.....	20	0
	14	Clay vitrified, telephone	.....	50	0
	14	Concrete, telephone	.....	50	0
	14	Fibre, telephone	.....	20	0
	14	Iron, telephone	.....	20	....
	14	Wood, creosoted	.....	20	....
	14	Conduit, subsidiary, telephone	.....	15	....
	15	Main, telephone	2	....	....
	15	Subsidiary	7	....	....
	6	Electric Light and Railway. Foster	.....	30–50	....
	24	Power. Standard Handbook	.....	2–30	....
	40	Ducts system of mains	.....	30	....
	41	Public service plants. N. S. Hill	3–5	....	....
	45	Conduit and cables. Cardiff	3	....	....
Cranes	25	Power-house	.....	15	....
Cross arms	1	Wisconsin Railroad Commission	8.3–12.5	....	....
	6	Electric Light and Power. Foster	.....	10–15	....
	6	Telephone. Wisconsin Commission	.....	8–12	....
	15	Telephone, data	11	....	....
Engines	1	Steam Traction Valuation Com., Chgo	3–5	....	....
	1	Steam. Arnold	5–7.5	....	....
	1	Steam. Henry Floy, New York P. S. C.	5	....	....
	1	Steam. Slow speed, Wis. R. R. Com	5	....	....
	1	Steam. High speed, Wis. R. R. Com	6.67	....	....
	1	Steam. Arbitrators, Atlanta	5	....	....
	1	Steam. St. Louis Public Service Com	6.67	....	....
	1	Gas. Wisconsin Railroad Commission	6.67	....	....
	10	Milwaukee. Pence	6.67–5	....	....
	11	Milwaukee Electric Railway and Lt. Co.	5	....	....
	12	Arnold	3–5	....	....
	13	Professor Gebbardt	4–6.6	....	....
	13	Chicago Traction Commission	3–10	....	....
	13	Chicago Union Traction	6.6	....	....
	13	Wisconsin Railroad Commission	5–6.6	....	....
	13	Average English and Scotch Practice	5	....	....
	13	Phillip Dawson	4–6	....	....
	13	Stone & Webster	5	....	....
	13	Steam, light service. Cravens	4–5	....	....
	13	Steam, heavy service. Cravens	5–6.6	....	....
	6	Gas	.....	10–15	....
	6	Corliss slow speed	.....	25–30	....
	6	Steam, high speed	.....	15–20	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Engines	16	Steam. Metcalf	.....	15–25	....
	19	Power-house	3–7	....	....
	20	Sir Henry Preece	.....	25	6
	21	Slow speed steam. Dawson	.....	24–40	....
	22	Electric railway	.....	25	....
	24	Prime movers. Standard Handbook	2.5–5	....	....
	29	Water works, engines and pumps	.....	30	....
	30	Locomotive, steam	.....	16	....
	37	Gas works	.....	25	20
	40	Steam. Hammond	.....	25	....
	41	Steam. Hill	4–6	....	....
	42	Slow speed, 10 hours per day	.....	25	....
	42	High speed, 10 hours per day	.....	15	....
	45	Engines and generators. Cardiff	5	....	....
Feeders	1	Wisconsin Railroad Commission	6.25	....	....
	10	And cables. Pence	4	....	....
	11	And cables. Milwaukee E. R. & Lt. Co.	5	....	....
	12	And cables. Arnold	1.5	....	....
	3	Feeder cables, overhead	3	....	....
	3	Feeder cables, leaded in ducts	4	....	....
	19	Feeder and transmission lines	5–12	....	....
Flumes	42	Wooden gates and racks. C. T. Main	.....	20	....
Foundations	1	Machine. Same as life of apparatus sup.	.....	....	....
	12	Arnold	6	....	....
	6	Same as machine supported	.....	....	....
Fuel oil handling machinery.	1	Traction Valuation Com., Chicago	4	....	....
Furnit ure (office).	7	Cooley. Milwaukee Three C't Fare Case.	8	....	....
	9	Starrett. Milwaukee Three C't Fare Case	5	....	....
	11	Milwaukee El. Ry. & Lt. Co	5	....	....
	3	Marwick, Mitchell & Co	5	....	....
	3	Telephone company	.....	4	....
	14	Telephone company	.....	10	0
Gas plant	37	Brick tanks. Prosser	.....	30	0
	37	Gas holders. Prosser	.....	30	5
	6	Gas holders. Wisconsin Commissions	.....	50	....
	37	Steel tanks and holders	.....	30	10
	37	Benches	.....	30	0
	6	Benches	.....	25	....
	6	Scrubbers and condensors	.....	30	....
	6	Purifiers, modern	.....	50	....
	37	Condensors, scrubbers, purifiers	.....	30	20
	6	Ammonia concentration	.....	15	....
	6	Ammonia storage tanks, wrought iron or steel	.....	15	....
	6	Water-gas machines, complete	.....	30	....
	37	Water-gas machines, complete	.....	25	25
Generators	1	Traction Valuation Commission, Chicago.	3–3	....	....
	1	Arnold. New York Public Service Com.	5	....	....
	1	Floy. New York Public Service Com.	5	....	....
	1	Modern type. Wisconsin Railroad Com.	5	....	....
	1	Obsolete type. Wisconsin R. R. Com.	6.67	....	....
	1	Steam turbo. Wisconsin R. R. Com.	5	....	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Generators	1	Arbitrators. Atlanta	10	....	....
	1	St. Louis Public Service Commission	6.67	....	....
	10	Milwaukee Three Cent Fare Case. Pence.	5	....	....
	11	Milwaukee Electric Railway and Lt. Co.	7.5	....	....
	12	Arnold	5	....	....
	3	(Steam) turbines and generators	6	....	....
	13	Belted. Prof. Gebbardt	3.3–4	....	....
	13	Direct connected. Prof. Gebbardt	3.3–4	....	....
	13	Belted, light service. Cravens	4–6.6	....	....
	13	Belted, heavy service. Cravens	5–8.3	....	....
	13	Direct connected, light service. Cravens.	3–5	....	....
	13	Direct connected, heavy service. Cravens	4–6.7	....	....
	13	Direct connected. Chicago Trac. Com.	5	....	....
	13	Direct connected. Chicago Union Trac.	6.6	....	....
	13	Direct connected. Wisconsin R. R. Com.	5	....	....
	13	Average English and Scotch Practice	5	....	....
	13	Philip Dawson	4–8	....	....
	13	Stone & Webster	5	....	....
	6	Generators, motors and rotaries, modern.	.....	20	....
	6	Generators, motors and rotaries, obsolete.	.....	15	....
	6	Turbo-generators	.....	20	....
	19	And electrical apparatus	2–5	....	....
	20	Sir Henry Preece	.....	30	8
	22	Atkinson	.....	25	....
	23	Tri-City Railway	.....	15	....
	25	And transformers. Hutchinson	.....	25	....
	40	Hammond	.....	25	....
	41	N. S. Hill	7–12	....	....
	42	Generators, engines, batteries	4	....	....
	45	And engines. Cardiff	5	....	....
Heaters	1	Traction Valuation Commission, Chicago	4–6	....	....
	1	Feed water, closed. Wisc. R. R. Com.	3.5	....	....
	1	Feed water, open. Wisconsin R. R. Com.	3.5	....	....
	12	Arnold	3	....	....
	6	Foster	.....	20–30	....
Insulators	25	High tension. Hutchinson	.....	10	....
Lightning arresters.	3	Station type	.....	15–20	....
Meters	1	Electrical switchboard. Wisc. R. R. Com.	5	....	....
	1	Electrical service. Wisconsin R. R. Com.	6.67	....	....
	1	Electrical. St. Louis Public Service Com.	8	....	....
	6	Gas, customer's. Wisconsin Commission	.....	25	....
	16	Water	.....	20–30	....
	20	Electric. Sir Henry Preece	.....	12	....
	22	Electric. Atkinson	.....	10	....
	37	Gas, consumers	.....	30	0
	40	Electric. Hammond	.....	10	....
	33	Water. Wisconsin R. R. Commission	.....	25	....
Motors, stationary.	13	Chicago Traction Commission	5–10	....	....
	13	Chicago Union Traction Commission	6.6	....	....
	13	Milwaukee Electric Railway & Light Co.	5	....	....
	13	Wisconsin Railroad Commission	5	....	....
	13	Average English and Scotch Practice	5	....	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Motors, stationary,	13	Phillip Dawson	5–8	....	....
	13	Stone & Webster	5	....	....
	13	Prof. Gebbardt	5	....	....
	13	A. C. & D. C. light service. Cravens	4–6.6	....	....
	13	A. C. & D. C. heavy service. Cravens	5–8.3	....	....
	22	Atkinson	.....	20	....
	40	Hammond	.....	20	....
Overhead equipment, electric railway.	13	Chicago Union Traction	10–14	....	....
	13	Milwaukee Electric Railway & Light Co.	7.5	....	....
	13	Average Scotch Practice	3	....	....
	13	Phillip Dawson	4–8	....	....
	13	Stone & Webster	10–14	....	....
	13	Light service. Cravens	4–10	....	....
	13	Heavy service. Cravens	8.3–12.5	....	....
	38	"Lines." British Columbia Elec. Ry.	3	....	....
	47	"Electric distributing system"	8	....	....
Overhead lines, electric light.	24	Best constructed	5–10	....	....
	24	Poorly constructed	20–30	....	....
	24	Badly constructed	40–60	....	....
	41	Electric pole lines, wooden poles	12–15	....	....
Paving	7	Milwaukee Elec. Ry. & Lt. Co. Cooley	10	....	....
	8	Milwaukee Elec. Ry. & Lt. Co. Beggs.	8.5	....	....
	9	Milwaukee Elec. Ry. & Lt. Co. Starrett	8	....	....
	12	Milwaukee Elec. Ry. & Lt. Co. Arnold	10–25	....	....
	3	Block	2.5	....	....
	3	Asphalt	7.0	....	....
	3	Brick, macadam, etc.	4.5	....	....
	18	Granite block. Chicago Union Traction	.....	16	....
	18	Granite block. Stone & Webster	.....	16	....
	18	Cobble stone. Chicago Union Traction.	.....	25	....
	18	Cobble stone. Stone & Webster	.....	25	....
	18	Cedar block. Chicago Union Traction	.....	6	....
	18	Cedar block. Stone & Webster	.....	6	....
	18	Asphalt. Chicago Union Traction	.....	10	....
	18	Asphalt. Stone & Webster	.....	10	....
	18	Brick. Chicago Union Traction	.....	7.69	....
	18	Brick. Stone & Webster	.....	7.69	....
	48	Chicago Union Traction Co.	4–10	....	....
	49	Stone & Webster	4–10	....	....
	23	Tri-City Railway	.....	10–15	....
	47	Witness before Wisconsin R. R. Com.	10	10	....
Penstocks	42	Iron and steel. C. T. Main	.....	100	....
Pipes buried	6	Cast iron mains, incl. valves and fittings.	75–100		....
	6	Wrought iron mains and services, galvanized and incl. valves and fittings	.....	30–50	....
	6	Cast iron mains and services. Black	.....	25–35	....
	6	Lead services to buildings	50–100		....
	6	Cast iron mains, gas, 3 inch and 4 inch	.....	50	....
	6	Cast iron mains, gas, 6 inch up	.....	75	....
	6	Wt. iron and steel mains under 3 inch, gas	.....	20	....
	6	Wt. iron and steel mains over 3 inch, gas	.....	30	....
	6	Services, gas	.....	20	....
	16	Water, cast iron, large diameter	.....	50–75	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Pipes buried	16	Water, cast iron, small diameter	.....	20–40	....
	16	Steel pipe	.....	25–50	....
	16	Wood stave pipe	.....	20–30	....
	16	Wrought iron service, water	.....	15–30	....
	17	C. iron pipe, good soil, Los Angeles, W.W.	1.25	....	....
	17	C. iron pipe, poor soil, Los Angeles, W.W.	2.00	....	....
	17	Sheet steel and riveted iron, good soil	4.00	....	....
	17	Sheet steel and riveted iron, poor soil	6.77	....	....
	17	Wrought iron screw pipe, good soil	3.33	....	....
	17	Wrought iron screw pipe, poor soil	5.71	....	....
	17	Cement lined pipe, good soil	2.86	....	....
	29	Cast iron pipe. W. W. Troutwine	.....	80	....
	29	Steel pipes, valves, blow-offs and gates	.....	35	....
	37	Cast iron mains, gas	.....	70	10
	37	Services, gas	.....	25	0
Piping	1	And covering. Traction Valuation Com.	4.45	....	....
	1	And covering. Arnold	6	....	....
	1	And covering. Floy	5	....	....
	1	And covering. Wisconsin Railroad Com.	5	....	....
	1	And covering. Arbitrators, Atlanta	5	....	....
	1	And covering. St. Louis P. S. C.	6.67	....	....
	10	And covering. Milwaukee, Pence	5	....	....
	11	And covering. Mil. El. Ry. & Lt. Co.	7.5	....	....
	12	And covering. Milwaukee, Arnold	3.5	....	....
	13	Steam. Chicago Traction Commission	3.5–10	....	....
	13	Steam. Chicago Union Traction	6.6	....	....
		Average English and Scotch Practice	5	....	....
		Phillip Dawson	8–10	....	....
		Stone & Webster	5	....	....
	13	Stone & Webster. Prof. Gebbhardt	4–6.6	....	....
	13	Steam and water, light service. Cravens	4–5.5	....	....
	13	Steam and water, heavy service. Cravens	5.5–8.3	....	....
	16	Power plant. Foster	.....	20–30	....
	19	Power-house	3–6	....	....
	37	And pumps, gas. Prosser	.....	15	10
	40	And pumps, electric plant	.....	25	....
Plants, complete	25	Hydro-electric, equivalent average life	.....	19	....
	25	Transmission line, equivalent average life	.....	26	....
	25	Sub-stations, static trans	.....	20	....
	28	Electric Plant, during first few years. W. L. Abbott	15–20	....	....
	28	Electric plant. Arthur Williams	10	....	....
	28	Electric plant. New York Edison	8	....	....
	28	Municipal Eng. El. Lt. plants. Andrews.	3	....	....
	29	Electric light plants (conncted with water works)	.....	20	....
	31	Electric plant. Wisconsin R. R. Com.	4.5–5	....	....
	31	Water plant. Wisconsin R. R. Com.	1.5	....	....
	32	Av. life 9 electric plant. Wis. R. R. Com.	.....	17.46	....
	32	Av. life 6 gas plant. Wis. R. R. Com.	.....	32.68	....
	32	Av. life 7 El. Ry. plant. Wis. R. R. Com.	.....	18.02	....
	32	Av. life water plant. Wis. R. R. Com.	.....	65.25	....
	34	Av. life gas plant. Wis. R. R. Com.	.....	30	....
	35	Av. life water plant. Wis. R. R. Com.	.....	50	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Plants, complete.	36	Av. life electric plant. Wis. R. R. Com.	.....	17	....
	7	" Power plant." Cooley. Milwaukee Case.	8	....	....
	9	" Power plant." Starrett. Mil. Case..	8	....	....
	12	" Power plant." Arnold.....	2	....	....
	47	Entire plant (railway including cars)...	7.67	....	....
Poles.....	1	Steel. Floy. New York Pub. Ser. Com.	2	....	....
	1	Wood in concrete. Wis. R. R. Com....	5	....	....
	1	Wood in earth. Wisconsin R. R. Com.	5.5–8.33	....	....
	1	Iron. Wisconsin Railroad Commission.	2.5	....	....
	1	Wood. Arbitrators, Atlanta.....	10	....	....
	10	Iron. Milwaukee, Pence.....	2.5	....	....
	12	Iron. Arnold.....	2.5	....	....
	12	Wood. Milwaukee, Pence.....	8.33–6.67	....	....
	12	Wood. Milwaukee El. Ry. & Lt. Co...	7.5	....	....
	3	Iron. Marwick, Mitchell & Co.....	2.0	....	....
	3	Wood. Marwick, Mitchell & Co.....	7.0	....	....
	4	And cross arms.....	.....	10	....
	14	Cedar, 35 feet and under (telephone)...	.....	10–15	0
	14	Cedar, over 35 feet.....	.....	15–20	....
	14	Chestnut, 35 feet and under.....	.....	8–12	....
	14	Chestnut, over 35 feet.....	.....	12–15	....
	14	Pine creosoted.....	.....	20	....
	14	Poles and cross arms. Average exchange.	.....	10	....
	14	Poles and cross arms. Average toll....	.....	15	....
	15	Poles including cross arms telephone....	.....	14	....
	18	Iron. Chicago Union Traction and Stone & Webster.....	.....	20	....
	23	Tri-City Railway Company.....	.....	7	....
	38	British Columbia Electric Railway.....	10	....	....
	39	Kansas City Western Railway.....	5	....	....
Pumps.....	1	Traction Valuation Commission, Chicago.	5	....	....
	1	Arnold. New York Public Service Com.	5	....	....
	1	Floy. New York Public Service Com...	5	....	....
	1	Small steam. Wisconsin Railroad Com.	6.67	....	....
	1	Small steam. Arbitrators, Atlanta.....	5	....	....
	1	Small steam. St. Louis Pub. Serv. Com.	6.67	....	....
	12	Arnold.....	5	....	....
	6	Boiler feed.....	.....	15–20	....
	6	Geared power.....	.....	20–30	....
	6	Centrifugal.....	.....	20–30	....
	16	Water w'k's, pumping and aux. mach...	.....	20–30	....
	22	And pipe work.....	.....	25	....
	23	Tri-City Railway Co.....	.....	15	....
	29	Water works engines and pumps.....	.....	30	....
	37	And piping. Gas works.....	.....	15	10
	41	Public service plants.....	3–10	....	....
Rolling stock....	1	Open car bodies. Traction Val. Com...	4	....	....
	1	Open trailer bodies. Trac. Val. Com...	5	....	....
	1	Trucks. Traction Valuation Com.....	3.33	....	....
	1	Closed and open cars. Arnold.....	3.33	....	....
	1	Trucks. Arnold.....	3.33	....	....
	1	Trucks. Floy.....	5.00	....	....
	1	Car bodies and equip. Wis. R. R. Com.	6.67	....	....
	7	Cars, bodies and trucks. Cooley.....	8	....	....

Property	Ref.	Remarks	Depreciation per cent	Life years	Scrap value per cent
Rolling stock	8	Cars, bodies and trucks. Beggs	6.67		
	9	Cars, bodies and trucks. Starrett	6		
	10	Cars, bodies and trucks. Pence	5–6.66		
	11	Cars, bodies and trucks. Milwaukee El. Railway & Light Co	7.5		
	3	Cars and all equipment	5.9		
	13	Cars. Chicago Union Traction	5–8.5		
	13	Cars. Wisconsin Railroad Commission	5–6.6		
	13	Cars. Average English Practice	10		
	13	Cars. Average Scotch Practice	7.5		
	13	Cars. Phillip Dawson	4–6		
	13	Cars. Stone & Webster	5–8.5		
	13	Cars and equipments, light service	5–8.3		
	13	Cars and equipment, heavy service	6.6–10		
	19	Car bodies and trucks	5–7		
	23	Car bodies		15	
	23	Car equipment		10	
	38	British Columbia El. Ry. rolling stock	3.5		
	30	Kansas City Western rolling stock	7.5		
	43	Cars (European)	1.7		
	44	Cars (English)	8.0		
	45	Cars. Cardiff	10		
	47	Cars and equipments	8		
	48	Cars, bodies and trucks. Ch. Un. Tr. Co.	5		
	49	Cars, bodies and tr'ks. Stone & Webster.	5		
	18	Electric car equipment. Gen. El. No. 57.		15	
	19	Electric car equipment	6–10		
	23	Electric car equipment		10	
	8	Electric car equipment	8.5		
	48	Electric car equipment	6.67–8.5		
	49	Electric car equipment	6.67–8.5		
	11	Electric car equipment	6		
Rotary convertors	22	Electric Traction Weekly		20	
	40	Hammond		20	
	13	Chicago Union Traction Co	6.6		
	13	Milwaukee Electric Railway & Light Co.	5		
	13	Wisconsin Railroad Commission	5		
	13	Average English and Scotch Practice	5		
	13	Phillip Dawson	8–10		
	13	Stone & Webster	5		
	13	Prof. Gebbhardt	4		
	13	Light service. Cravens	3–5		
	13	Heavy service. Cravens	4–6.6		
Shop equipment electric railway	7	Cooley. Milwaukee Three C't Fare Case.	8		
	9	Starrett. Milw'kee Three C't Fare Case.	7		
	10	Pence. Milwaukee Three C't Fare Case.	3.33–10		
	13	Chicago Traction Co	3–10		
	13	Chicago Union Traction Co	5		
	13	Milwaukee Electric Railway & Light Co.	7.5		
	13	Wisconsin Railroad Commission	3.3–10		
	13	Average English Practice	7.5		
	13	Average Scotch Practice	7.5		
	13	Phillip Dawson	12–15		
	13	Stone & Webster	5		
	13	Light service. Cravens	5–10		

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Shop equipment electric railway	13	Heavy service. Cravens	7.5–15	....	....
	23	Atkinson	.....	25	....
	44	"Workshop Tools & Sundry Plant"	2	....	....
	47	Witness before Wisconsin Railroad Com.	8	12.5	....
	3	Machine tools	5	....	....
	3	Hand tools	10	....	....
Stacks	1	Traction Valuation Com., Chicago	3	....	....
	1	Steel. Arnold. N. Y. Pub. Serv. Com.	10	....	....
Stokers	1	Fixed parts. Traction Valuation Com.	5	....	....
	1	Moving parts. Traction Valuation Com.	20	....	....
	12	Arnold	25	....	....
Storage batteries.	1	Floy. N. Y. P. S. C. 3rd Ave. Railway.	5	....	....
	1	Wisconsin Railroad Commission	6.67	....	....
	1	St. Louis Public Service Commission	5	....	....
	3	Marwick, Mitchell & Co	3	....	....
	13	Prof. Gebbhardt	6.6	....	....
	13	Light service. Cravens	5–6.6	....	....
	13	Heavy service. Cravens	6.6–10	....	....
	6	Foster	.....	10–15	....
	20	Sir Henry Preece	.....	15	10
	40	Hammond	.....	15	....
	13	Chicago Union Traction	6.6	....	....
	13	Milwaukee Electric Railway & Light Co	10	....	....
	13	Average English & Scotch Practice	5	....	....
	13	Phillip Dawson	9–11	....	....
	13	Stone & Webster	5	....	....
Switchboard	1	And wiring. Traction Valuation Com.	3	....	....
	1	And wiring. Arnold, N. Y. P. S. C.	6	....	....
	1	And wiring. Floy, New York P. S. C.	5	....	....
	1	And wiring. Modern Type, W. P. S. C.	5	....	....
	1	And wiring. Obsolete Type, W. P. S. C.	6.67	....	....
	10	Milwaukee Three Cent Fare Case. Pence	2	....	....
	48	Chicago Union Traction Co	6.66	....	....
	49	Stone & Webster	6	....	....
	11	Milwaukee Electric Railway & Light Co.	5	....	....
	13	Chicago Traction Commission	2	....	....
	13	Chicago Union Traction Co	6.6	....	....
	13	Wisconsin Railroad Commission	2	....	....
	13	Average English Practice	7.5	....	....
	13	Average Scotch Practice	5	....	....
	13	Phillip Dawson	8–10	....	....
	13	And instruments, light service	2–5	....	....
	13	And instruments, heavy service	5–8.3	....	....
	6	And wiring, modern type	.....	20–30	....
	6	And wiring, obsolete type	.....	15–20	....
	25	Hydro-Electro station. Hutchinson	.....	10	....
	40	Switching apparatus and instruments	.....	20	....
	45	And instruments	7.5	....	....
	14	Telephones, central office	.....	8–10	....
Telephones	1	Wisconsin Railroad Commission	10	....	....
	14	Subscriber's station equipment	.....	8–10	....
	6	Central office equipment. Wis. Com.	.....	10	....
	6	Subscribers sets	.....	10	....
	15	Central office equipment	7	....	....
	15	Subscribers' station equipment	12.5	....	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Towers, transmission.	25	C. T. Hutchinson	.....	15	....
Track	1	Rail joints. Traction Valuation Com..	5	....	....
	1	Ties. Traction Valuation Commission..	5	....	....
	1	Special works. Wisconsin Railroad Com.	8.5	....	....
	1	Straight track. Wisconsin R. R. Com..	5.5	....	....
	7	Main track. Cooley	8	....	....
	8	Main track. Beggs	8.5	....	....
	9	Main track. Starrett	8	....	....
	48	Main track. Chicago Union Trac. Co.	7.75	....	....
	49	Main track. Stone & Webster	7.2	....	....
	11	Main track. Milwaukee El. Ry. & Lt. Co.	7.5	....	....
	10	Special work. Pence	7–12.5	....	....
	48	Special work. Chicago Union Traction.	7.75	....	....
	49	Special work. Stone & Webster	7.2	....	....
	11	Spec. work. Milwaukee El.Ry.& Lt.Co.	12	....	....
	12	Special work. Arnold	.....	10	....
	3	Special work. Marwick, Mitchell & Co.	9	....	....
	3	Rails in city streets. Marwick, Mit. & Co.	4.5	....	....
	3	Rails in country rds. Marwick, Mit. & Co	3.5	....	....
	3	Rails in private right-of-way	3.5	....	....
	3	Sub-structure in city streets	4.5	....	....
	3	Sub-structure in country roads	7.0	....	....
		Sub-structure in private right-of-way...	10	....	....
	13	Wisconsin Railroad Commission	5	....	....
	13	Average English Practice	5	....	....
	13	Average Scotch Practice	8	....	....
	13	Phillip Dawson	7–13	....	....
	13	Stone & Webster	7.2	....	....
	13	Light service. Cravens	5–8.3	....	....
	13	Heavy service	7.5–12.5	....	....
	18	Electric. Chicago Union Traction	.....	12.85	....
	18	Electric. Chicago Union Traction	.....	12.85	....
	18	Electric. Stone & Webster	.....	13.86	....
	18	Cable. Chic. Un. Tr. and Stone & Webster	.....	14.53	....
	18	Horse. Chic. Un. Tr. and Stone & Webster	.....	12.29	....
	19	Rails and ties	8–15	....	....
	19	Special work	10–20	....	....
	23	Ties, Tri-City Railway	.....	7	....
	23	Rails. Tri-City Railway	.....	14	....
	38	British Columbia Electric Railway	2	....	....
	39	Kansas City Western. Rails 55c. per ton	.....	....	....
	39	Kansas City Western. Ties	12.5	....	....
	41	N. S. Hill	8–12	....	....
	45	And bonding. Cardiff	5	....	....
	47	Witness before Wisconsin Railroad Com.	8	12.5	....
Transformers	1	Station service. Wisconsin R. R. Com.	5	....	....
	1	Station service. Wisconsin R. R. Com.	6.67	....	....
	1	Station service. St. Louis P. S. C.	6.67	....	....
	13	Chicago Union Traction	6.6	....	....
	13	Milwaukee Electric Railway & Light Co.	5	....	....
	13	Average English Practice	5	....	....
	13	Average Scotch Practice	5	....	....
	13	Phillip Dawson	5–6	....	....
	13	Stone & Webster	5	....	....

Property	Ref.	Remarks	Depreciation, per cent	Life years	Scrap value, per cent
Transformers	13	Prof. Gebbhardt	4	....	....
	13	Light service. Cravens	3–5	....	....
	13	Heavy service. Cravens	4–6.6	....	....
	6	Service transformers. Foster	.....	10–15	....
	22	Railway station	.....	15	....
	23	Tri-City Railway Company	.....	25	....
	25	Transformers and generators	.....	25	....
	25	Sub-station	.....	20	....
	40	Static. Hammond	.....	25	....
	45	And motors. Cardiff	5	....	....
Turbines, steam.	1	Wisconsin Railroad Commission	5	....	....
	1	St. Louis Public Service Commission	6.67	....	....
	13	Milwaukee Electric Railway & Light Co.	5	....	....
	13	Average English Practice	5	....	....
	13	Average Scotch Practice	5	....	....
	13	Phillip Dawson	7–8	....	....
	13	Stone & Webster	5	....	....
	13	Prof. Gebbhardt	4	....	....
	13	Light service. Cravens	3–4	....	....
	13	Heavy service. Cravens	4–5	....	....
	22	Atkinson	.....	20	....
	40	Hammond	.....	30	....
Turbines, water.	1	Wisconsin Railroad Commission	3.33	....	....
	6	Built before 1900. Foster	.....	25–40	....
	6	Built after 1900. Foster	.....	30–50	....
	25	C. T. Hutchinson	.....	25	....
	42	C. T. Main	.....	25	....
Wire, trolley	1	No. 0 — Under one minute headway.	50	....	....
	1	No. 00 — Under one minute headway.	40	....	....
	1	No. 000 — Wisconsin Railroad Com.	33.3	....	....
	3	Marwick, Mitchell & Co	5	....	....
	18	No. 0 — Chicago Union Traction Co. and Stone & Webster.	.....	7	....
	18	No. 00 — Chicago Union Traction Co. and Stone & Webster.	.....	10	....
	19	Electric Traction Weekly	6–15	....	....
	23	Tri-City Railway	.....	14	....
Wire, weather-proof.	1	Wisconsin Railroad Commission	6.25	....	....
	1	Arbitrators, Atlanta	7.5	....	....
Wire, miscellaneous.	4	Copper, telephone	.....	15	....
	14	Copper, telephone bare, exchange	.....	10–15	40
	14	Copper, telephone twisted pair	.....	10	10
	14	Iron, telephone bare, exchange	.....	8–10	0
	14	Copper, telephone toll	.....	40	40
	14	Iron, telephone toll	.....	15	0
	15	Copper, telephone bare, exchange	5	....	....
	15	Iron, telephone bare, exchange	14	....	....
	15	Copper, telephone bare, toll	2	....	....
	15	Iron, telephone bare, toll	8.5	....	....
	25	Copper, power transmission	.....	25	....

Discussion of Report of Committee on Life of Railway Physical Property

MR. KELKER:— In connection with the report, one thing that strikes me as very important is that we are at the present time engaged or surrounded by those who are engaged in making valuations of properties, and if we have information at hand that can be used in making an accurate determination of value, we will have a fine record that can be used as a check on those who agree or disagree with us. Also in having the data, we will be able to arrive at a clearer idea of values of the various portions of the property and thus make arrangements to take care of necessary renewals. It will give us a chance to have, at hand, facts as records and not estimates. I think the report should be referred back to the Committee for continuation, as suggested by the Committee itself.

MR. SCHREIBER:— Permit me to explain further that your Committee did not rely solely on its own data and experience in arriving at the conclusions set forth in the report; but the subject was separated into five divisions, representing the field naturally covered by the five standing committees of the Engineering Association. Accordingly, we selected fifty gentlemen, ten for each division, whom we considered eminently fitted to express an opinion of the life of that portion of railway property with which they were particularly identified. Letters were forwarded to these gentlemen and in return many interesting replies were received and valuable assistance rendered.

A great deal of discussion was given to the question of creating a table that was generally applicable for the Life of Railway Physical Property. It is interesting to note that a number of authorities consulted did express opinions in favor of such a list. Now, if your Committee was in error in the position finally taken of the apparent impossibility of producing such a table, it certainly will welcome any discussion for or against the conclusions as were finally decided.

MR. SIMMONS:— I might say in the beginning, as a good many of you know, I am at the present time no longer connected with street railway interests, but, as I have had experi-

ence in this line for a good many years past, and I have come very intimately in contact with the valuation by a state commission of one of the large companies of the country. I may therefore possibly have been one of the gentlemen whose testimony, before such a body, might have seemed to indicate the idea that the life of physical property could be given in terms of a general average.

I would like to say that in my opinion the Committee is right in the position they have taken. I do not believe that it is possible to say that the life of a car is so much. In this connection I am reminded of a question which I am now receiving as a public official of a large city, and that is, "What is the best pavement?" It is ridiculous on the face of it. I think, in giving testimony on the valuation of properties in Wisconsin, as particularly applied to the Milwaukee Electric Railway & Light Company's property, the evidence, which we various heads of departments gave, was based on our own analysis of the average life of physical property in that particular company. I think that life would vary, in each different section of the country, and in cities of varying size and under many other conditions. I do not see how it would be possible to strike an average for the general membership of this Association. I think, however, that the greatest amount of good can be done by assembling, as the Committee's report states they have assembled, all the available data which was secured through such valuations as were made in Milwaukee and many other points throughout the country, and possibly tabulating, or at least indexing the findings so they could be made available to all the various member companies as they come in contact with this valuation proposition. I do not think that an attempt to strike a general average would be of any value at all. I know that we arrived at general averages in Milwaukee, but they only applied to Milwaukee conditions, not even to the conditions in the cities surrounding Milwaukee.

Mr. Adams:— Mr. Chairman, the Committee has laid down the principle, which is well founded as I see it, but it is one that will require a continuous follow-up system because the question of striking an average value is a very difficult

one, particularly in the age that we are passing through at the present time. Having in mind particularly the question of equipment, we do not know today what the life of the car or motor of today will be and it is necessary to keep up-to-date records in order to obtain this information. The form in which the Committee has outlined this work is, I believe, one that our Associations can well afford to follow in the future.

MR. HAM :— I approve thoroughly of the method which the Committee has followed in prescribing some standard classification of physical property. I believe it is a very important field of work for these two Associations. The fact that there are great difficulties in arriving at any ascertainment of facts, should not discourage us in an effort to obtain whatever information we can. This is a live subject, and one that receives judicial consideration, and according to the way the law is today, it is necessary for some one to state what the depreciation on a property is. Now, it is not easy to get away from it and say it cannot be done; it is done, and has to be done, because in determining the present value of a property it is customary to arrive, first, at the reproduction value of new property, and then to make proper allowance for depreciation. Therefore, it is something that some one must do; it is something that is done by experts, and it is something that the street railroads, for their own interests, must make an effort to ascertain.

It is going to take many years to get at anything that is reliable and valuable, and yet on certain items covered by these classifications we may already have data that is of value. We probably all have an idea of the average life of a tie, under different conditions. An engineer must know that, and he must have some idea of the relative life of untreated and treated ties. So there are items under this classification on which we must have already some information, and by following this thing up for years, as will be necessary, we will come to a time when we will have something which may be of value. One thought I would like to refer to is, that in the study of depreciation, we want to eliminate entirely the question of obsolescence, because obsolescence and depreciation are

two absolutely different things. The life of the property is the normal life, if not thrown away, and in the future, correct accounting principles will differentiate between obsolescence and depreciation.

MR. WILSON:— The recommendations of the Committee should be followed. The life of all parts of electric railways is an important subject for every company. Each can obtain the most useful information by keeping careful records of its own. The data obtained in one city is not applicable to another and the average of data obtained from separate cities is almost valueless to use in another place for different conditions.

MR. SCHREIBER:— There is one thing that did not occur to me when I omitted the list. It may be possible that we have not gone far enough in the division of the general classification, or probably we have gone too far, and I think I had better read the list, so if there is anyone of the opinion that we should change it, or who has any suggestion on it, we may have it on record for next year's Committee.

(Mr. Schreiber then read the list of items embodied in the report.)

You can readily see that you could itemize the list and get any number of items under these subdivisions; but we attempted to select those that would be representative. Under the division of "Equipment," we have put six items. If anyone wants to say anything about a particular classification, I wish he would interrupt, and we will hear the discussion. Shop tools, I might say, includes all machinery connected with the shop.

The heating plant would be part of the building under the first heading. Of course you could go into heating plant. There are many kinds of heating plants. That is the point. It would be almost impossible to go into the equipment of a building like a heating plant and the wiring. It seems necessary to take the building as a unit.

MR. BOYLAN:—As to the equipment, it occurred to me there might be a subdivision under "car bodies" — as between wood and steel bodies.

MR. SCHREIBER:— That is a good suggestion. With the large tendency toward steel bodies, it would be very pertinent.

MR. BOYLAN:— You might have three subdivisions of it, combination, steel and wood.

MR. BARNES:— The subdivision as between wood and steel car bodies, especially in the matter of depreciation, is so largely dependent on the degree of maintenance, that you might call it a function of the maintenance. The difficulties of maintenance of a steel body are entirely different and separate from the difficulties of maintenance of a wooden body. It seems to me the two ought to be considered separately.

MR. SCHREIBER:— Under "Power Distribution" we have twelve items. (Reading the list of items.) You will notice we have not put anything under "shop and tools." Large companies always have shop and tools in this branch, but we considered the item covered under equipment. Mr. Rice, of Chicago, is here, and I would like to hear what he has to say about the classification.

MR. RICE:— I cannot discuss the matter now. I have just heard the report for the first time, but it occurs to me, as you read the items, there is a distinction between "feeders" and "cables."

MR. SCHREIBER:— One is conduit. We only used two items here. You might say an ordinary weatherproof insulated feeder for cable, and lead covered in a duct. Those are the two items we wanted to bring out. I realize that a feeder does not have to be necessarily weather proof. We have different kinds of insulation. So with each item we could subdivide, but if you would have absolute data on the twelve given, wouldn't it be fair to assume that you could anticipate very closely the remainder?

MR. RICE:— A classification of the electrical transmission and distribution items has been made by the Board of Supervising Engineers, in which the items are called "principal parts" and they constitute the unit in determining renewal values for street railway property under the ordinance. These principal parts as thus established by the Board are as follows:

(a) Poles and fittings.
(b) Trolley wire.
(c) Span wire and fittings.

(d) Special overhead trolley work.
(e) Overhead feeder.
(f) Underground feeder.
(g) Cross bonds and negative auxiliary return cable.
(h) Conduits, manholes and vaults.
(i) Submarine cables.
(j) Joint bonds and auxiliary cable at special work.
(k) Miscellaneous — such as despatching system.

Shouldn't we include, possibly, concrete poles? And there is no mention made of rail box?

MR. BOYLAN:— I think transmission lines should be covered also.

MR. KELSAY:—You make no mention of arms as separate and distinct from other transmission material.

MR. SCHREIBER:— No. I want to beg pardon for drawing this discussion out, but I am doing it because I think it will be such a great help to the Committee next year. I don't know where we would have an opportunity to get this information if we did not get it in this way. We might write letters, but you know letters are not always answered. Under "Power Generation" we have fourteen items. (Reading list of items.)

MR. FRENCH:— I think, under present methods a great many state commissions are classifying bonds as part of the distribution system, rather than of the track system.

MR. BOYLAN:— Under our distribution the bonding is done by the line department, and I think it should be placed there.

MR. SIMMONS:— The matter of bonding I think is open to question. My own opinion is, that you will find the track department of many of the large systems takes care of the bonding instead of the line department.

MR. DATZ:— I think when all these questions are sent to the companies an extra question should be added as to climatic conditions. I think that this has an important bearing on the life of all the properties.

MR. ROBERTS:— I was called in not long ago to report on values for a company where two types of motors were pointed out to me and declared to be obsolete. Everybody had accepted that, but I did not. I said that I would take those

motors, and try them out, on the road. I found that the motors that had been declared obsolete were the best motors that the company possessed for their particular requirements. I was asked the question, "why was it the manufacturing companies were not pushing the making of this type of motors?" The answer, to my mind, was this: That the companies had to make motors that they could put into the hands of salesmen and sell under almost any conditions. I believe that we ought to have some definite record, or some recognized standard on depreciation. It seems to me that we could not have anything more interesting than the replies Mr. Schreiber has received to the Committee's questions.

Mr. Schreiber:— Yes, Mr. Roberts, the replies received from the gentlemen selected were quite different in a number of cases. This was principally due to different view points; for example, one man might take obsolescence into consideration, and another would not. Mr. Ham said that in his judgment obsolescence should not be taken into consideration; but it seems to me that you cannot very well anticipate the life of any item of railway property without its consideration. Obsolescence due to the advancement of the art appears to have as much to do with how long you are going to use an item as its actual useful wear. I am of the opinion that there are a number of men in this country who could reasonably anticipate its life if you were going to use the item as you are using it today; and of course assuming the degree of maintenance is known. But, who is going to say what changes in the art we are going to have in the next ten or fifteen years and who is able to anticipate the acts of Providence?

Mr. Roberts:— There is another view of the matter; for instance, equipment that would last indefinitely on one system, under certain track conditions, would not last very long under other conditions on a different system.

Mr. Ham:— I am very glad that I have heard these remarks about obsolescence. Unless you are going to set yourselves up as good guessers, the only thing to deal with is depreciation. Obsolescence may be general in character or local. Who could have said, when we had horse cars that the

time would come very shortly when everything connected with the horse car equipment was going to be discarded? Was it proper that the horse car operator in those days should have tried to include in his expenses a fund sufficient to take care of the entire loss of his investment, which he could not foresee and which no one else could foresee? Take a local condition, a motor that is perfectly good becomes from local operating conditions obsolete with the company using it. It may be so with that company, but it has not become entirely obsolete. I think in approaching this subject you should keep in mind that you are dealing only with depreciation and not with obsolescence.

CHAIRMAN HIXSON:— I will call on Mr. Schreiber to close the discussion.

MR. SCHREIBER:— As the time is very short, I will detain you only a moment. In behalf of your Committee I desire to state that this discussion has been very gratifying. It seems to demonstrate the wisdom of joint meetings of the Engineers and Accountants on such an important question as we have before us. Also, I desire to take this opportunity in behalf of the Committee to extend our appreciation to all the gentlemen and members of the Accountants' and Engineering Associations who have co-operated with the Committee in this discussion and in furnishing data for the final report.

MR. ADAMS:— I move that the report of this Committee be accepted, that a vote of thanks be extended to the Committee and that the Committee be continued for a further investigation of the subject.

(Motion seconded, stated and carried.)

CHAIRMAN HIXSON:— That, I believe, completes the joint session and the Accountants Association will adjourn to the Orange Room, there to hold its regular session.

(Joint session concluded and a recess of three minutes declared.)

THURSDAY MORNING SESSION

OCTOBER 10, 1912 — (*Continued*)

The regular meeting was called to order by President Ackerman at 12.05 P. M.

PRESIDENT ACKERMAN:— Gentlemen! We have another matter to take up this morning which is of importance to the Association. I wish to place before you a letter received by me from our Secretary, Mr. Litchfield, which is as follows:

NEW YORK, N. Y., *September*, 11, 1912.

Mr. E. O. ACKERMAN, *President, Executive Committee:*

DEAR SIR.— The writer has come to the conclusion that the field of the Engineering Association has broadened to such an extent that the interests of its members would be best served by the consolidation of the office of its Secretary with that of the American Association. The detail work has been rapidly increasing and to continue the present policy of having as Secretary an engineer actively engaged in professional work, would, in my judgment, require the regular employment of paid assistants.

This would, of course, involve considerable expense and, furthermore, the experience of the past year convinces me that the work could be more effectively handled in the office of the general secretary.

I therefore present my resignation to take effect upon the election of the new officers at the coming Convention.

Yours very truly,

NORMAN LITCHFIELD,
Secretary-Treasurer.

MR. CLARK:— Gentlemen, last year I was on the Committee on Nominations and we placed Mr. Litchfield in nomination for Secretary. This is his first year and I am sorry to note that he has concluded to give up this work. Of course he knows what we say but not what we mean. He has to put it into shape so it can be put into the record in good form. I move that Mr. Litchfield's resignation be accepted.

MR. KELSAY:— I have been connected with the Association for some years, during a portion of which time Mr. Litchfield had been the Secretary. It has been a pleasure to me to associate with him in our various committee meetings. I first came in contact with Mr. Litchfield while I

was a member of the Executive Committee and always found he showed himself exceedingly active and interested in the work of the Association. The work which he has had to do as Secretary, in addition to his other duties with his Company, has certainly involved a very considerable amount of labor and I can appreciate the reason he desires to be relieved of the duties as Secretary of the Association. I therefore second the motion to accept the resignation of our Secretary, not because we want to see Mr. Litchfield retire from the office, but because we feel that his request to be relieved of the work should be recognized.

PRESIDENT ACKERMAN:— The Executive Committee highly appreciates the valuable services of Mr. Litchfield. We also realize the fact that the work of his office has grown to such magnitude that it is not reasonable to expect a man who has other professional work to take care of, to give it the necessary attention. It is too much.

The Association has grown to be such a large institution that it is not possible to adequately handle the work in this way and we must make other arrangements.

(The motion to accept Mr. Litchfield's resignation was put before the house and carried.)

MR. ADAMS:— If I may rise for a moment, I want to add a few words in reference to Mr. Litchfield. The work that Mr. Litchfield has done for the past two years has been of the greatest value to the Engineering Association. From an engineering standpoint he has carried the work forward in excellent shape. We all consider him a very good engineer in the particular line which he has been following out. I do not know whether you are aware that he has other lines of engineering in which he dabbles now and then. The latest one I have heard of was to the effect that he is supposed to be an expert bob sledge engineer. As near as I can find out the only difficulty about his engineering in that respect was that his weights per bob were so great that the cost of carrying a pound per year has not been figured out yet.

While I am on my feet, Mr. President, I want to express to Mr. Litchfield the appreciation of his associates in this

organization for his valued services, and in order that he may have a small token by which to remember the work that he has done, I desire to present this to him on behalf of his friends and associates in the Association. Mr. Litchfield, I have great pleasure in presenting this keepsake to you. (Mr. Adams then presented to Mr. Litchfield a gold watch and chain.)

SECRETARY LITCHFIELD:— I thank you all. You have had to listen to me very patiently a good many times during this meeting and I will therefore say, "Good bye, and thank you all very much."

MR. KELKER:— We all regret sincerely the fact that the President of the American Association has not been able to be with us, on account of his illness. We certainly miss him. Therefore, I make a motion to the effect that the Secretary be instructed to wire the thought, that the A. E. R. E. A. extends to President McCarter its regrets at his inability, through illness, to be present at this Convention, and also its well wishes for his speedy recovery.

PRESIDENT ACKERMAN:— Such action will be taken as the unanimous expression of the meeting.

We will now have the report of the Committee on Way Matters which will be presented by Mr. J. M. Larned, chairman of the Committee.

MR. LARNED:— There were a number of subjects submitted to the Way Committee this year for report, but the Committee did not find time in which to conclude its work on all the subjects submitted.

The principal subjects on which the Committee reports at this time are those of Rail Sections and Joints therefor, Alloyed Steel Rails and a Revision of the Specifications for Open-Hearth Girder and High T-Rails. These are probably the only subjects that have been reported on in sufficient detail to warrant discussion, and I believe we should discuss each one of them separately.

With reference to that part of the report covering rails and joints, the Committee received from the Way Committee of last year a proposed section of girder-grooved

rail nine inches deep and was requested to design guard rails for the same, to submit proposed sections for 7 in. girder-grooved and girder-guard rails and to design joints to match these sections. This has been done and the Committee has recommended that these rail sections and joints be adopted as Recommended Practice. However, these recommendations have not been approved by the Committee on Standards and, therefore, the subject will be referred back to the ensuing Way Committee. It is desired at the present time that a full discussion and criticism of these rails be had for the benefit of the succeeding Committee. The principal objections that were found to these rail sections were technical objections by some of the experts in the special work manufacturing end, and related principally to the width of the groove in the guard rail; to the amount of metal in the tram of the straight line rail; and in the neck of the groove of the guard rail.

With reference to the joints, I wish to call attention to the method of designating compromise joints, which appears on page 591 of the report. The Committee has not thought this a proper subject for standardization and consequently has not brought it to the attention of the Committee on Standards. However, it is a novel suggestion, covering a new method of designating compromise joints, former methods having always resulted in considerable confusion, and the Committee recommends that the Secretary be directed to call the attention of member companies and of all special work manufacturers and joint manufacturers to this method, so that it may become the universal practice without being put to letter ballot by this Association and made one of its Standards.

REPORT OF THE COMMITTEE ON WAY MATTERS

To the American Electric Railway Engineering Association:

GENTLEMEN.— The following subjects were assigned to the Committee for investigation this year.

From the Executive Committee:—

(1) Nine-Inch Girder-Grooved and Guard Rail, and Seven-Inch Girder-Grooved and Guard Rail, embracing the principles outlined in the report of the Committee on Way Matters for 1911.

(2) Consideration and further development of Rail Joint outlined in the report of the Committee on Way Matters for 1911.

(3) Proper Ballast for Tracks in paved streets.

(4) The use of Titanium, Nickle and Chromium, or any other cleansing material in the manufacture of rails. This subject to be handled by the Subcommittee appointed from the Way Committee to act in conjunction with the American Society for Testing Materials in regard to the matter of steel in rails.

(5) The use of T-rails in streets.

(6) Proposed change in Track Gauge for electric railways.

From the Committee on Standards:—

(7) A revision of the books of Rules and Regulations for the Government of Employes of the Way Department as proposed by the Committee on Way Matters for 1911, and an investigation of methods and systems of operation, and of standard installations, with a view to incorporating in the Uniform Code such additional instructions and rules relating thereto as may seem desirable for their adoption as "Standard."

From President Ackerman:—

(8) The consideration of a Uniform Method for Designating Compromise Joints.

Two sessions of the Committee were held as follows: The first at New York, at Association Headquarters, January 26, 1912, present; Mr. F. G. Simmons, *Chairman*, Messrs. C. L. Crabbs, J. M. Larned, C. S. Kimball, B. E. Tilton, Chas. H. Clark and E. H. Berry. At this meeting the subjects assigned the Committee were apportioned to Subcommittees for investigation and primary treatment; and the membership of the Subcommittees and the subjects alloted each were as follows:—

Subcommittee No. 1.

(a) Nine Inch Girder-Grooved and Guard Rail; Seven Inch Girder-Grooved and Guard Rail.

(b) A Joint for these Rails.

(c) A Uniform Method for Designating Compromise Joints.

Mr. H. F. Merker, *Chairman,* Messrs. R. F. Kelker and C. S. Kimball.

Subcommittee No. 2.

Proper Ballast for Tracks in Paved Streets.

Mr. C. H. Clark, *Chairman,* Messrs. C. L. Crabbs and E. H. Berry.

Subcommittee No. 3.

(a) The use of Titanium, Nickle and Chromium or any other Cleansing Materials in the Manufacture of Rails.

(b) The Consideration and Preparation of a Specification for Splice Bars for Girder and High T-Rails.

(c) A revision of the Associated Specification for Open Hearth Girder and High T-Rails, in conjunction with a Committee of the American Society for Testing Materials.

Mr. J. M. Larned, *Chairman,* Messrs. B. E. Tilton and C. W. Gennett, Jr.

Subcommittee No. 4.

The use of T-Rails in Streets.

Mr. F. G. Simmons, *Chairman,* Messrs. B. E. Tilton and C. H. Clark.

Subcommittee No. 5.

The Revision of the Rules and Regulations for the Government of Employes of the Way Department.

Mr. C. S. Kimball, *Chairman,* Messrs. J. M. Larned and C. L. Crabbs.

The second session was held at Niagara Falls, May 20 and 21, 1912, present Mr. F. G. Simmons, *Chairman,* Messrs. J. M. Larned, H. F. Merker, E. H. Berry, C. H. Clark and C. L. Crabbs. At this meeting the Committee learned with regret of the resignation of Chairman Simmons, he having severed his connection with the field of electric railway work. At the request of President Ackerman the duties of the Chairman were undertaken by Mr. Larned, and Mr. Clark consented to act in Mr. Simmons' place as Chairman of Subcommittee No. 4.

At this meeting progress reports of the Subcommittees were considered, also the completed revision of the Specifications for Open Hearth Girder and High T-Rails.

The following joint meetings were held by Subcommittee No. 3

with Subcommittee No. 1 of Committee A 1 of the American Society for Testing Materials, for the consideration of the Specifications for Open Hearth Girder and High T-Rails:—

Atlantic City, October 10, 1911, Messrs. Larned and Voynow (of the 1911 Committee) representing your Association.

At Philadelphia, January 11, 1912, Messrs. Larned and Voynow representing your Association; your Association was also represented at a meeting of Committee A–1 held at New York February 24, 1912, by Messrs. Larned and Gennett; also at the Annual Meeting of the American Society for Testing Materials at New York, March 27 and 28, by Mr. Larned.

With reference to the matters under consideration, your Committee begs to submit the following report.

NINE INCH GIRDER-GROOVED AND GUARD RAILS; AND SEVEN INCH GIRDER-GROOVED AND GUARD RAILS

The following brief reference is made to the work of previous Committees upon this subject, as a matter of record.

The Committee on Way Matters for 1907 presented for consideration several sections of girder and girder-guard rails (Vol. 1, pages 120–127 1907 Proceedings), recommending for use in Cities where T-rail was not approved, the nine and seven inch girder-grooved rails shown upon pages 122 and 123 of said volume.

The Committee on Way Matters for 1909 confirmed the report of the 1907 Committee (Vol. 1, page 44 1909 Proceedings), recommending these two sections for adoption as "Recommended Practice" upon streets "where the traffic is confined to the railway strip, or is so congested that the railway strip is continually used by vehicles."

The Committee on Way Matters for 1910 approved the principles outlined in previous reports and submitted other matters for consideration.

The Committee on Standards for 1910 (page 502, 1910 Proceedings), approved the recommendations of the 1909 Committee on Way Matters and these recommendations were approved by the Convention (page 513, 1910 Proceedings).

The Committee on Way Matters for 1911, made a careful revision of the work of the previous Committees and submitted a nine-inch girder-grooved section, and an analysis of the principles involved in its design (pages 520–525, 1911 Proceedings) and recommended that further consideration of the nine-inch girder-grooved, a nine-inch girder-guard rail and a seven-inch girder-grooved and guard rail be undertaken by the 1912 Committee.

It will be seen, therefore, that none of the various girder rail sections submitted have received the final approval of your Association.

The rail section submitted by the 1911 Committee and the principles involved in its design seem to have met with very general approval, though it was not considered advisable to take action upon this section, without a corresponding guard rail and without providing at the same time for seven-inch girder-grooved and guard rails.

This section is, therefore, again submitted, as Fig. 1 of this report, with the approval of your present Committee. A reprint of the principles involved is not shown, as this is thought to be unnecessary. Your Committee also submits proposed sections for seven-inch girder-grooved rail and nine and seven-inch girder-guard rail, Figs. 2, 3 and 4 respectively.

In the design of these sections your Committee has been guided by the following considerations, in addition to those outlined by the 1911 Committee.

Seven-Inch Girder-Grooved Rail

HEAD, TRAM, TREAD AND FISHING SURFACES:

As the duties required of these parts are not affected by the depth, logically they should follow the same lines in nine-inch and seven-inch rail.

BASE:

The width of base should be unaffected by the depth in respect to wear upon it and upon the structure immediately supporting it, but with regard to stability the width may be reduced. A proportionate reduction without going into any unnecessary fractions, was therefore made and the width of base taken at 5½ in. The thickness of the flange at the edge taking into consideration loss from corrosion and the difficulty of rolling and filling out very thin flanges, has been left the same as in the nine-inch rail. This and the angle of the fishing surface fixed by last year's report, determined the thickness of the base at other points.

WEB:

The web has been merely reduced from the bottom, giving it the same strength that it had in the nine-inch rail.

Girder-Guard Rail

HEAD, TRAM, TREAD AND FISHING SURFACES:

It is essential that these rails should fish perfectly with their connecting girder-grooved rail; all dimensions, angles and surfaces which affect the fit of the splice bars are therefore fixed as well as the depth of the head and any widening of the base becomes undesirable, as it would call for a decrease in thickness at the outer edge. We believe

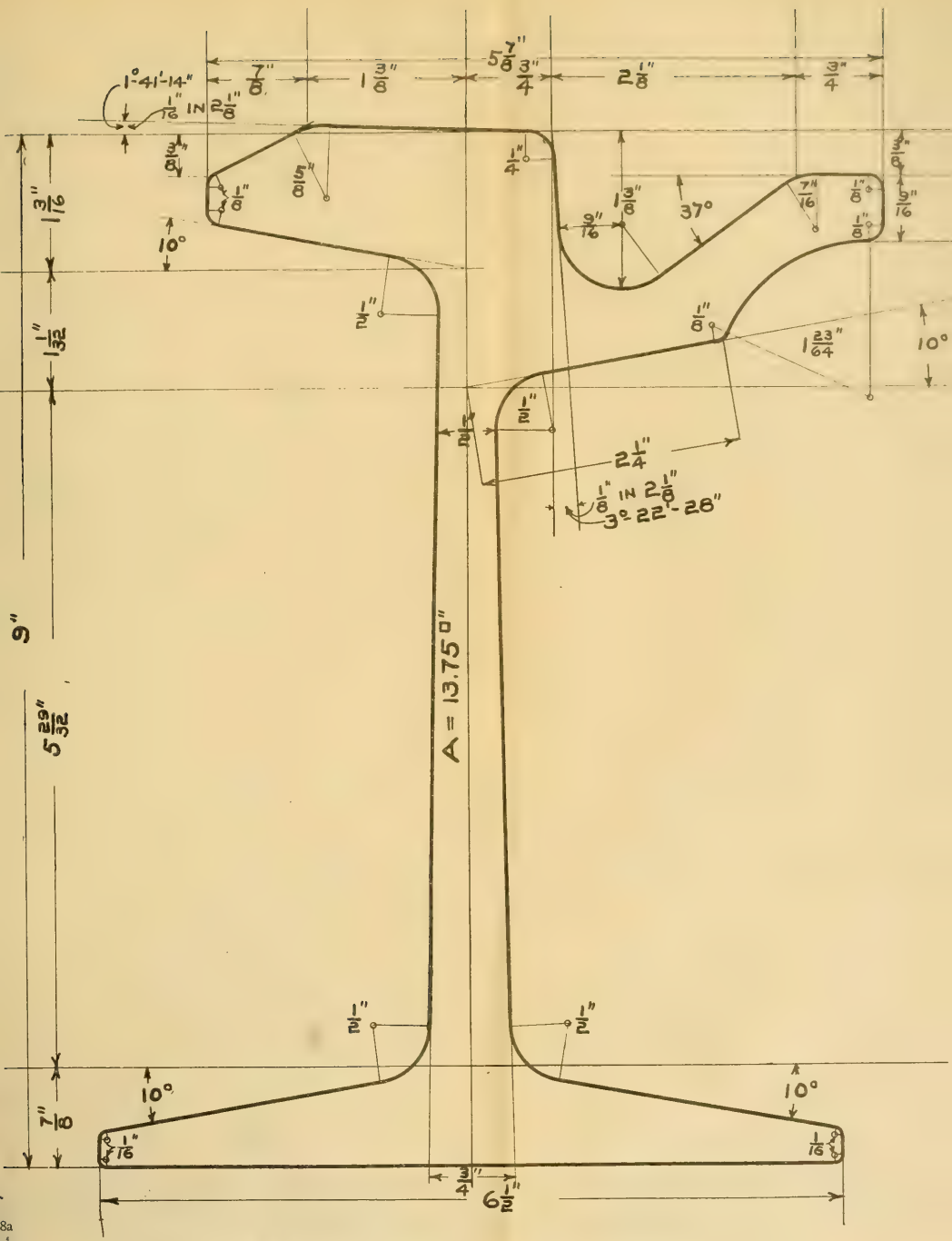

FIG. 1. SHOWING 9 IN. GIRDER-GROOVED RAIL RECOMMENDED AS STANDARD.

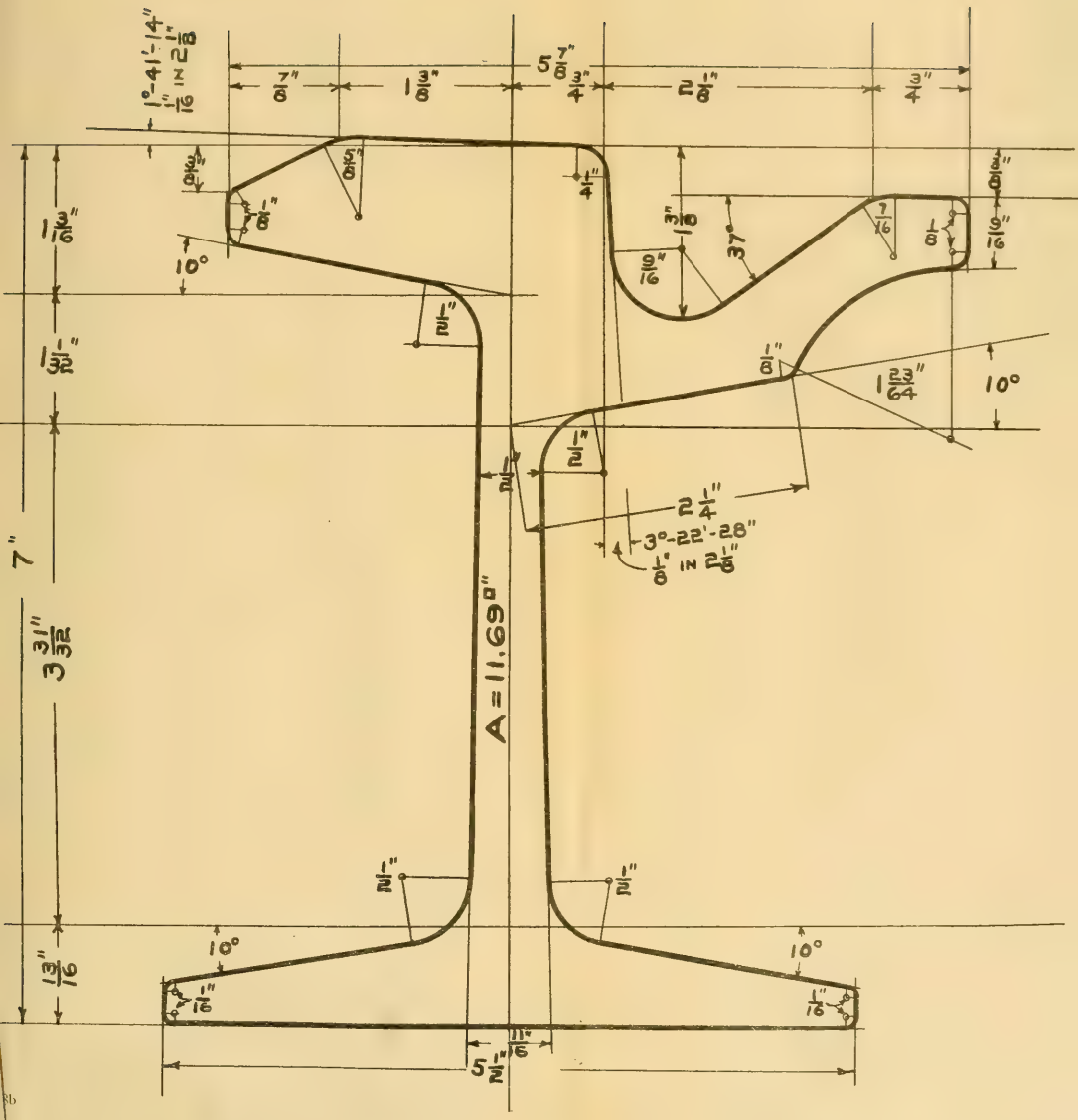

FIG. 2. SHOWING 7 IN. GIRDER-GROOVED RAIL RECOMMENDED AS STANDARD

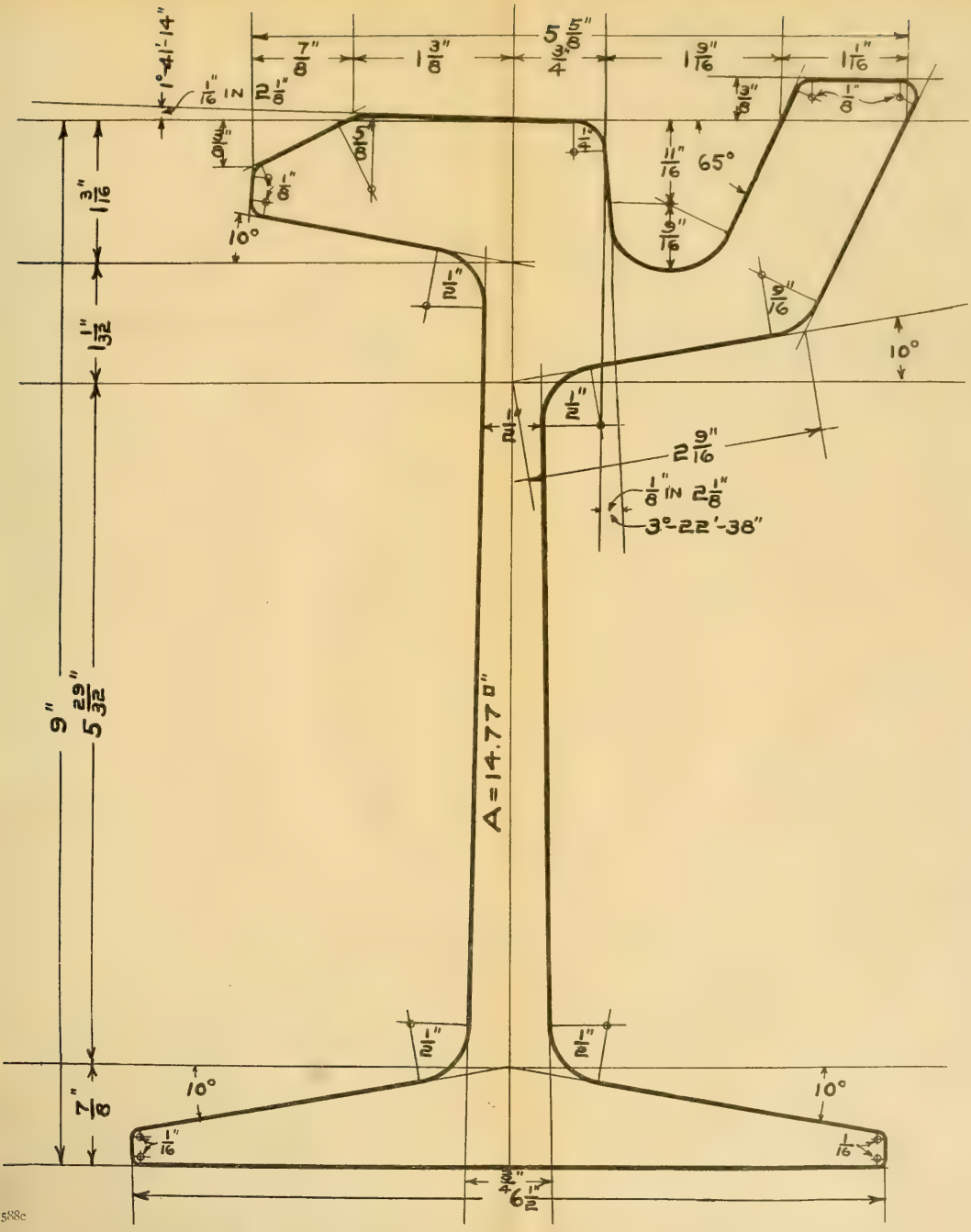

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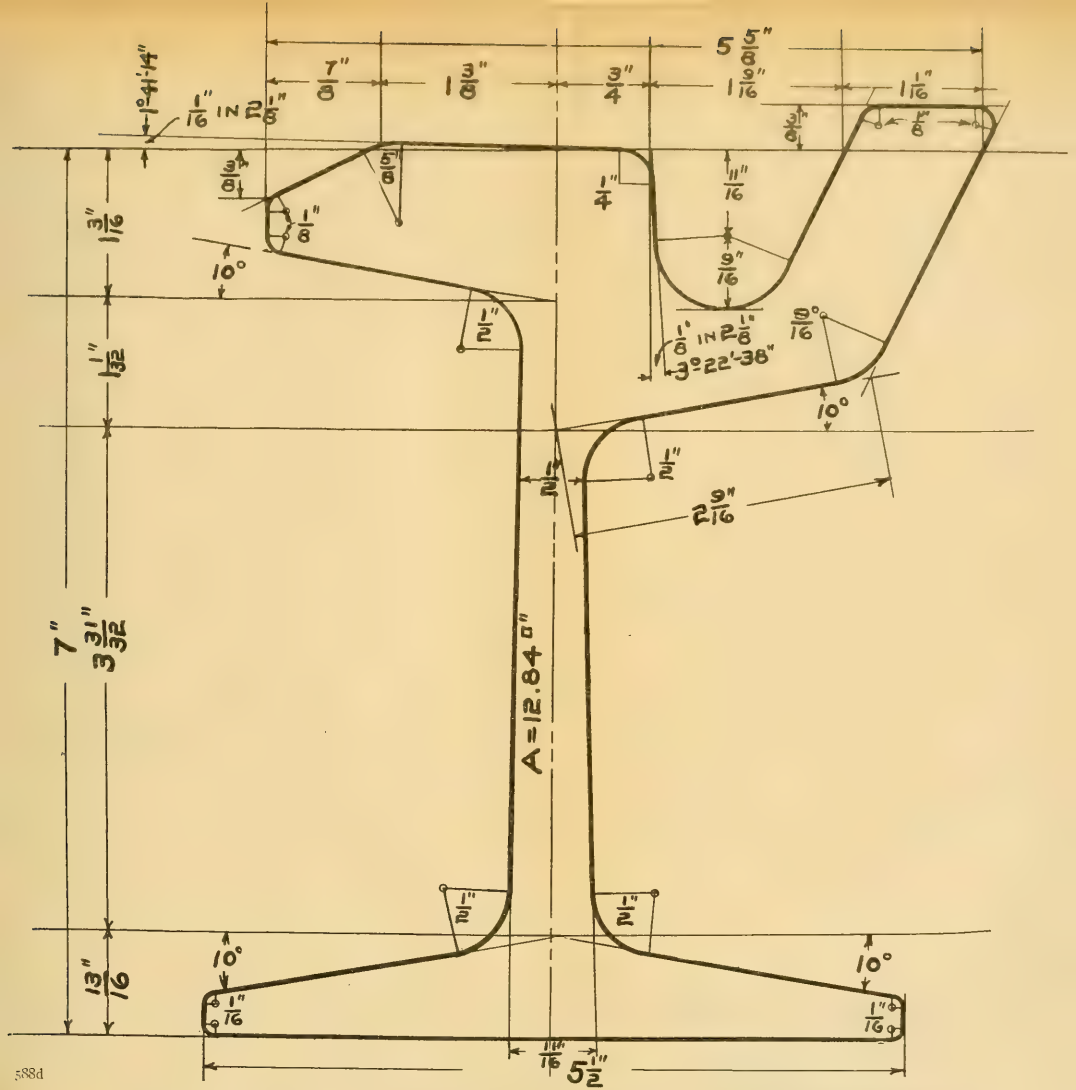
Fig. 3. Showing 9 in. Girder-Guard Rail Recommended as Standard for Use in Curves and Special Track Construction with the 9 in. Girder-Grooved Rail Shown in Fig. 1.



588d

FIG. 4. SHOWING 7 IN. GIRDER-GUARD RAIL RECOMMENDED AS STANDARD FOR USE IN CURVES AND SPECIAL TRACK CONSTRUCTION WITH THE 7 IN. GIRDER-GROOVED RAIL SHOWN IN FIG. 2.

that all dimensions of these rails should agree with those of the girder-grooved with which they are intended to connect, with the exceptions of those dimensions which are affected by the groove and guard.

The desirability of combining in one design all the essentials for a practical groove and guard is evident. Theoretically a different width groove is required for each radius, wheel base and wheel flange, but operating conditions do not permit of such refinement since cars of different wheel base and having both new and worn wheel flanges must use the same curve, nor is such refinement necessary when we consider that the groove, during the major portion of the life of the guard-rail cannot, through wear, meet the theoretical requirements.

THE GROOVE:

The consideration of curve-worn rail would indicate that the slope at the gauge side of the head should not be as steep as the corresponding slope for straight-line rail, but for better alignment along the gauge line at connections, this slope and top fillet has been made to conform with that of the connecting section.

The slope at the guard side of the groove conforms practically to that required for a wheel flange of the Association Standard with a six-foot wheel base upon a curve of fifty-foot radius.

The width of the groove, 1 9/16 in., level with the tread, is sufficient to pass the Association Standard wheel flange on a forty foot radius curve.

The depth of the groove, 1¼ in., is, we believe, sufficient to provide for all vertical wear upon the head of the rail during its life which is usually limited by curve wear upon the sides of the head and guard. The depth is limited by the fixed fishing dimensions of the straight line rail and by the thickness required for the guard at the neck.

GUARD:

The accepted practice of raising the guard ⅜ in. above the head of the rail has been adhered to, though we recognize that this forms some slight obstruction to vehicular traffic and is largely the cause of the more rapid wear and rutting of pavement in and around special work.

The thickness of the guard is sufficient to permit considerable wear, without reducing the strength so far as to make it useless. The reduction in depth of groove provides sufficient metal at the neck of the guard to prevent it from bending or breaking at this point.

These rail sections have not been submitted to the manufacturers by this Committee for their consideration, it believing that all the essential features were covered in consultation with last year's Committee.

We recommend that these girder-groove and girder-guard rails as shown in Figs. 1, 2, 3 and 4 of this report be adopted as "Standard."

DESIGN FOR JOINT PLATES

(For use with Rails proposed in this report)

The Committee on Way Matters for 1910 presented a progress report upon the subject of Rail Joints, setting forth the essential elements for obtaining a satisfactory rail joint, and giving a brief description of the principal types of joints.

The Committee on Way Matters for 1911 submitted for further consideration a proposed form of bolted joint plate.

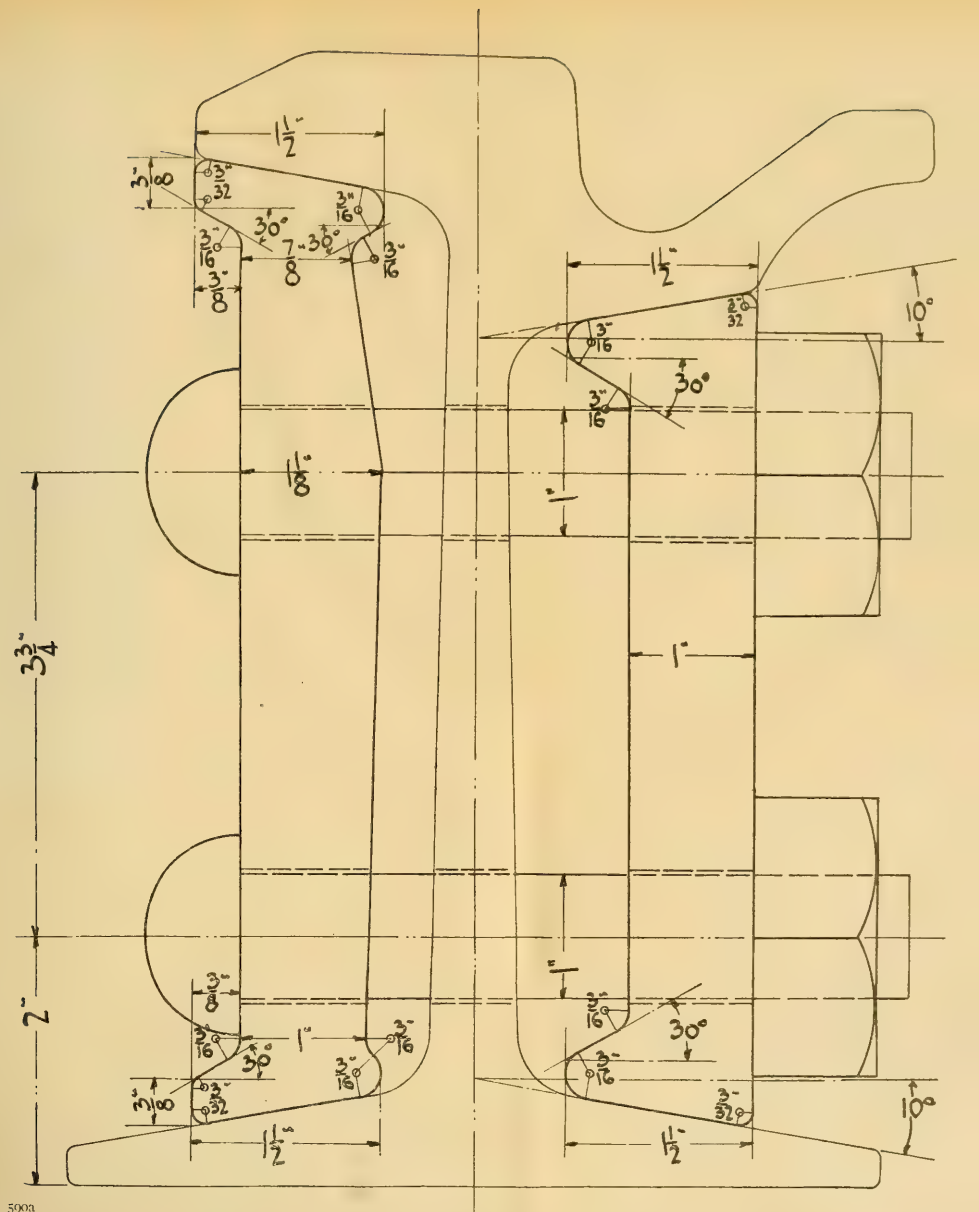
Your Committee has confined its consideration of this subject to the plain channel-plate type of bolted joint as outlined by the 1911 Committee, believing that there is at present a very large demand for a joint of this type, and that this demand will continue for some years. Your Committee also believes that the design for rails as submitted with this report, would not be complete unless accompanied by a design for joint plates. The relative merits and demerits of this type of rail joint as compared with other specialized and, for the most part, patented joints have not been considered.

Failures may be attributed largely to insufficient fishing surface or insufficiency of metal in the web, either of which faults may cause a line contact, or nearly so at the fishing surfaces, thereby materially decreasing the life of the joint; the former is defective in that the contact surface approximates a line, and the latter in that the plate will bend or buckle under the load applied by drawing up the bolts, thus giving a line contact between plate and rail. An inspection of the rails and joint plates shown in the catalogs of manufacturers, will furnish many examples of rails lacking in fishing surfaces, and of plates which do not avail themselves to the full extent of the limited surfaces presented.

Your Committee believes that the life of this style joint will be materially increased, at small additional cost to the completed track structure, when a plate is designed of such strength and stiffness that it cannot be bent under any load applied when tightening the bolts, particularly when supplied with channel contact surfaces of such width as the head of the rail will permit.

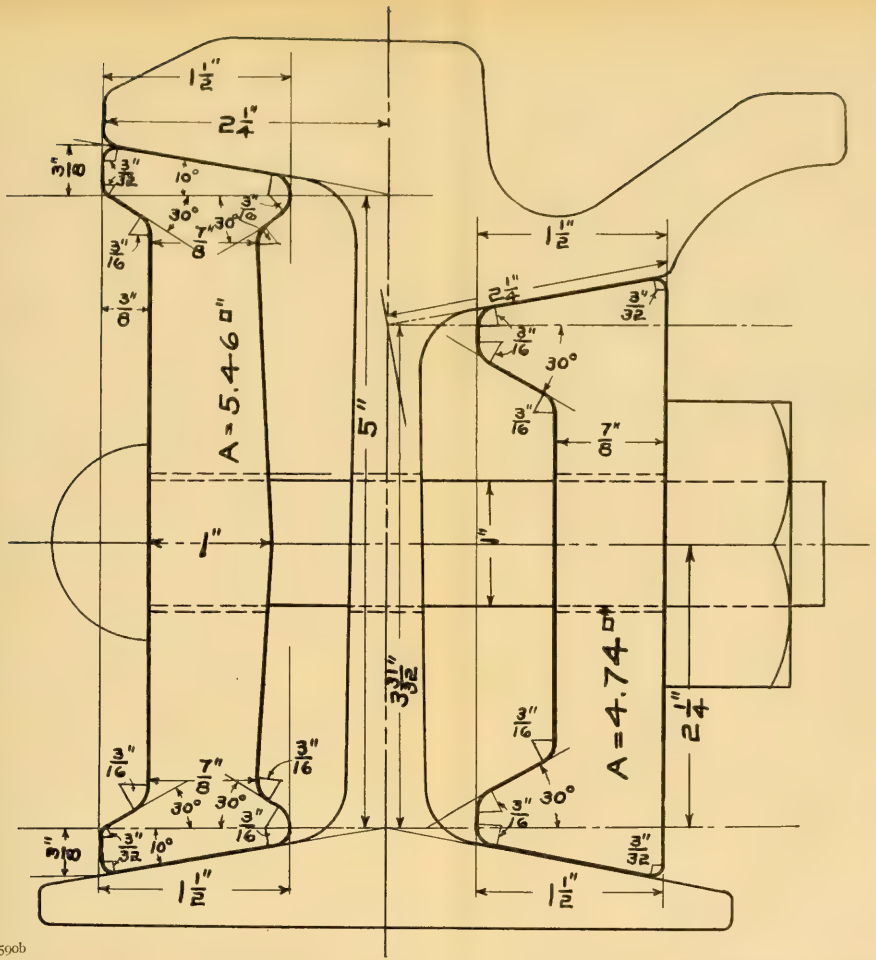
We have not considered it necessary to go into a detailed consideration of the proper length for these plates believing that the customary lengths, 26 in. for a six-bolt joint on seven-inch rail, 32 to 36 in. for 12-bolt joint on nine-inch rail, are correct, and we prefer for the present at least, to leave undetermined and to the judgment of the individual purchaser, the question of the size of the bolt and of the hole for the same in plate and rail.

Though not essential to the life of the joints, we believe ample space should be provided when practicable, under the joint plates, for bonding purposes.



500a

FIG. 5. SHOWING BOLTED JOINT FOR 6 IN. GIRDER-GROOVED AND 6 IN. GIRDER-GUARD RAILS IN FIGS. 1 AND 3 RECOMMENDED AS RECOMMENDED PRACTICE.



590b

FIG. 6. SHOWING BOLTED JOINT FOR USE WITH 7 IN. GIRDER-GROOVED AND 7 IN. GIRDER-GUARD RAILS SHOWN IN FIGS. 2 AND 4 RECOMMENDED AS RECOMMENDED PRACTICE.

Believing that the joint plate for nine-inch rail, submitted by the 1911 Committee on Way Matters and described upon page 525 of the 1911 Proceedings, conforms to the requirements, we submit the same as Fig. 5, with our approval, and have also prepared a design for joint plates for 7-inch rail along the same general lines which we approve and submit as Fig. 6.

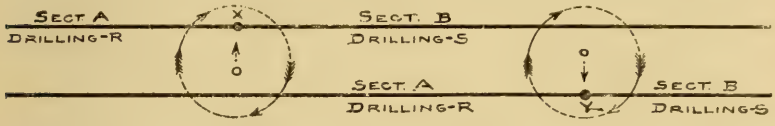
Your Committee recommends these joint plates as shown in Figs. 5 and 6 for use, with bolted joints in connection with the rails shown, Figs. 1, 2, 3 and 4 as "Recommended Practice."

A UNIFORM METHOD FOR DESIGNATING COMPROMISE JOINTS

There has been considerable complaint on account of the confusion caused by the various conflicting methods used in naming Compromise Joints and the Committee has been asked to make an investigation of the subject with the view to recommending a uniform method of designation.

It seems that all companies who manufacture Compromise Joints designate them either as "right hand" or "left hand" and it develops further, that what one Company calls a "right hand" joint another Company calls a "left hand" joint — due to material differences in their definitions of what constitutes a "right" and "left."

Your Committee can see no good reason why the term "left hand" or "right hand" should be used with its consequent cumbersome definition and has therefore agreed upon a logical method of naming these joints. This method which is illustrated in Fig. 7 of this report recommends itself because of its brevity and simplicity and the Committee thinks it may be used without fear of confusion or mistakes.



Observer stands between rails at O, facing joint. All readings left to right, as in reading a book, and as indicated by arrows. Joint X would read: One combination joint connecting Sect. A worn ¼ in.; drilled R with Sect. B worn — Drilled S. Joint Y would read: One combination joint connecting Sect. B worn — Drilled S with Sect. A worn — Drilled R.

FIG. 7. SHOWING A PROPOSED METHOD OF DESIGNATING COMPROMISE JOINTS.

It is recommended for approval upon the floor of the Convention, with the suggestion that the illustration be sent to all special work and joint manufacturers as well as to the heads of the Way Departments of our Member Companies.

PROPER BALLAST FOR TRACKS IN PAVED STREETS

Your Committee has been unable to make a report upon this subject, due largely to the fact that replies to Data Sheets sent out have not been received, and recommends that the subject be continued and referred to the 1913 Committee.

ALLOYED STEEL RAILS

This subject has not heretofore been under consideration by the Association in its present general form, though Manganese rail received some brief mention by the Committee on Way Matters of 1909 (page 59, 1909 Proceedings). The attention of the secretary of the American Society for Testing Materials has been called to this subject with the view, should his Society see fit, to having this question form part of the co-operative work between that Society and this Association but as yet there has been no definite action taken along these lines. No circulars calling for data and information upon this subject have been sent out during the year, though your Committee has corresponded with individual members of the Association, also with officials of some of the steam railroad companies interested, and we desire to submit the following review as tending to show the lines along which investigation is being made.

The treatment of steel for rails with various alloys has been a question of study and experiment for several years, the chief object sought being to prolong the life of rails by the addition of hardening and toughening qualities, preserving at the same time the ductility necessary to insure freedom from brittleness. Important limitations are at the very outset imposed, primarily, the cost of the finished rails and secondly, the odd shaped or unbalanced sections of rails — which preclude the possibilities of heat treatment, are matters which prevent as rapid development of the subject as would otherwise be possible.

For the sake of brevity these remarks are confined to the common methods used in attaining the desired result, which is a moderate priced, long-lived rail of any section immediately available in any quantity. Therefore, it is only necessary to take up the subject of titanium, manganese and nickel-chrome rails, for while there are various other known alloyed steels, their use in rails with the limitations mentioned, makes their consideration here unnecessary.

FERRO-TITANIUM STEEL:

The addition of the alloy ferro-titanium to either Bessemer or open-hearth steel is to-day the most common method of seeking to prolong the life of steel rails without materially increasing their cost. The alloy is, as the name indicates, composed chiefly of iron and titanium, the latter being a chemical element found in various ores and conspicuous for having great affinity for oxygen. The manufacture of the alloy renders obtainable in it, various proportions of titanium, so that a 15 per cent. alloy means that nominally there is that amount of titanium present as against 85 per cent. of iron, but these figures are not fixed and allowance must be made for the presence of other ingredients, as carbon, aluminum, etc. The theory on which the

use of ferro titanium is advocated is very simple, hinging upon the affinity that titanium has for oxygen, and largely upon the effect of chemical reactions that occur from its addition to the molten steel, resulting in a cleansing, so that the name "scavenger" has often been applied to the alloy.

There are two brands of ferro-titanium alloy available for use. The one known as the Rossi process is most frequently used, and differs principally from the other or Goldsmith alloy, because of being practically free of aluminum. The latter brand contains from four to six per cent. of aluminum, which is a deoxidizing element often used in casting steel to reduce piping and blow holes.

The amount of titanium alloy to be used is a matter of some argument, but in short it may be said, that enough should be added to thoroughly saturate the molten metal with titanium. Theoretically then, a trace of titanium in the finished steel may be regarded as proof that enough has been added to the molten steel to effect complete deoxidation. Recent practice advises the addition of one-tenth of one per cent. metallic titanium to either Bessemer or open-hearth steel, and while this figure may be taken as a safe minimum, there is abundant reason to think that a larger amount would be more satisfactory, especially under some conditions. The use of the alloy requires close attention to detail in the steel works, and should be attended with such supervision as will insure a strict adherence to the recognized principles and specifications governing its use.

Success due to the use of titanium has resulted from a denser, more uniform, and homogeneous metal, as might be expected from the nature of its duty as a scavenger. Granted that the metal is clarified by using titanium, the possibility of increasing the carbon content without a material loss of ductility occurs, so that of late many tons of rails have been made containing more carbon than formerly whose wearing qualities are regarded as greatly increased, and with no loss of shock resisting qualities. Recommendations as to the carbon content as well as to the other usual elements had best be left to the individual case, at least until more definite information has been obtained.

We believe when used under proper metallurgical conditions, that titanium alloy increases the wearing qualities of rails, sufficient evidence having been produced as a result of careful measurement to justify such conviction. Whether the increased wearing quality is economically profitable to the purchaser, is a different question, depending upon the first cost of the rails, and experience with grooved girder and high T-rails for street and interurban uses, has not been sufficient to make accurate figures obtainable.

MANGANESE STEEL:

Manganese steel is invariably a high carbon open-hearth steel containing from 12 to 15 per cent. of manganese. Steel having such a proportion of manganese present, when quenched in water from a red heat becomes exceedingly hard and tough, but remains sufficiently ductile to resist impact. The manufacture of rails of such composition has attained considerable headway in the last few years, and it is now possible to produce any section if ordered in fair quantity. The process is quite simple, involving principally the addition of a large amount of ferro-manganese to the open-hearth metal. The treatment of the ingots in the soaking pits must be attended with great care, and finally after rolling and sawing to length, the rails must be immediately immerged in a tank of water. Naturally the long lengths become very crooked when thus cooling, so that a greater amount of cold straightening often becomes necessary. A very tough and ductile steel results, the most objectionable feature of which is the impossibility of sawing or drilling it, and therefore, careful ordering to length and punching of all holes is necessary. While the price of manganese steel rails quite precludes their common adoption for straight track, still for curves and in special or hard service track the benefits derived are such as to warrant their careful consideration.

NICKEL-CHROME STEEL:

Some large tonnages of nickel-chrome steel rails were rolled for steam roads several years ago, in which the nickel and chromium were additions to the steel of the open-hearth furnace and have given splendid wearing results, although it is true that the rate of breakages has been high. Since that time, however, there has come into common use a large supply of iron ore, known as Cuban ore, containing nickel and chromium, therefore rendering unnecessary any addition of these elements to the molten steel in the open-hearth furnace or converter. The use of this Cuban ore at some of the Eastern mills, has made the alloy steel available at no increase of price, and its composition running close to one and one-half per cent. of nickel and one-half of one per cent. of chromium, seems to add very desirable qualities to rail steel, making it in many respects comparable to steel with a furnace addition of three and one-half per cent. of nickel.

Several thousand tons of this Mayari steel, as it is called, by both Bessemer and open-hearth process have been laid in steam road track since its first offering in 1910, but as yet the results as to its wearing qualities and breakages are still largely unavailable. Many electric railway companies have also used this steel for girder rails and the results of all will be watched with much interest, for indications point

to a cheap, hard, tough and ductile steel, which is much needed for rails.

It may be well here to mention the possibilities in using an increased amount of silicon in common open-hearth steel for rails. Steel with as high as four-tenths of one per cent. of silicon, or double the high limit used in this country, is reported to have given excellent wearing results on English roads. Certainly the matter is worthy of consideration.

Your Committee presents the above as a progress report and believes that definite conclusions can be more properly arrived at after the results of the practical service tests of these alloys that are now being made have become known.

THE CONSIDERATION AND PREPERATION OF SPECIFICATIONS FOR SPLICE BARS FOR GIRDER AND HIGH T-RAILS

This subject has not heretofore been under consideration by this Association and your Committee believes this to be an important matter, and that the lack of specifications has often resulted detrimentally to our Member Companies, in that the softest kind of steel may be obtained in joints intended to connect abutting pieces of very hard rail.

Through lack of time and inability to hold another meeting, we regret that definite and well considered specifications cannot be presented with this report. Your Committee believes that proper specifications should provide for two grades of steel, one moderately soft, which may be used in the various patented bolted joints now on the market as well as with the softer grades of steel rail, the other quite hard and more suitable for use with the high Carbon open-hearth rails, which are coming into more general use on electric roads.

The latter grade will be somewhat more expensive than the former, owing to the necessity of punching them hot, and also because all manufacturers are not equipped to do this hot punching. Specifications of this description should receive careful detailed consideration by the Committee in joint session with representatives of manufacturers. Proposed specifications for consideration at such a meeting have been prepared by one of the members of the Committee, but as it has not received the necessary consideration as outlined above, it cannot receive the approval of the Committee at the present time. These specifications are submitted as Appendix A of this report.

Your Committee recommends that this subject, together with the specifications, be referred to the 1913 Committee on Way Matters, with the request that it be made one of their principal subjects of consideration.

A REVISION OF THE ASSOCIATION SPECIFICATIONS FOR OPEN-HEARTH GIRDER AND HIGH T-RAILS, IN CONJUNCTION WITH A COMMITTEE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS

The specifications of the Association referred to in this report were prepared and submitted to the Association by the 1910 Committee on Way Matters (pages 48–53, 1910 Proceedings), with the recommendation that they be approved as "Recommended Practice" (page 69, 1910 Proceedings.) This recommendation was approved by the Committee on Standards (page 684, 1911 Proceedings) and upon the floor of the Convention (page 701, 1911 Proceedings), but has not as yet received final approval, by letter ballot of the Association.

The revised specifications herein referred to have been prepared by a joint Committee consisting of a Subcommittee of Committee A-1 of the American Society for Testing Materials and a Subcommittee of the Committee on Way Matters of your Association, and also manufacturers and consumers other than the representatives of your Association. The revised specifications were approved by the American Society for Testing Materials, at its annual Convention held at New York, March 27–28, 1912, and have been put to letter ballot of the Society. Final approval has been received and they are now in the hands of its Form Committee for such revision in form, though not in substance, as may seem desirable.

The original and revised specifications together with the principal reasons for alterations are submitted as a part of this report under Appendix B.

In presenting these revised specifications to your Association the Committee wishes to state that it agrees with the Committee on Way Matters of 1910 and believes that uniform specifications will be of mutual benefit to consumers and manufacturers. We are entirely in accord with the 1910 Committee on Way Matters in believing that a high-carbon rail is desirable for use in city streets from an economical point of view, and that it may be used with safety in such service, although we do not wish to be understood as advocating the use of such rail in open or unpaved track under high speed conditions.

Your Committee considers that the revised specifications are more uniform in their requirements and recommends that they be adopted as "Recommended Practice," superseding the present specifications approved in 1911.

THE USE OF T-RAIL IN STREETS

The 1907 Committee on Way Matters issued circulars and collected data upon this subject and in 1909 (pages 120-129, Volume 1, 1907 Proceedings).

The Committee on Way Matters also issued circulars and collected further data upon this subject (pages 40–59, Volume 1, 1909 Proceedings). Their report is quite full and contains illustrations of the latest and most improved methods of installation and paving, as well as photographs of streets in various cities using T-rail and opinions of City Engineers in different parts of the country relating to the use of this type of rail.

Unfortunately the data collected by these committees has been mislaid, and it has been the purpose of this Committee to collect as far as practicable new data upon this subject which may be tabulated and filed in the records of the Association for future use when needed, and with this end in view your Committee directed a circular letter to the officials of 140 different cities, copy of which will be found in Appendix C of this report; as well as a circular letter to Member Companies, a copy of which also appears in this report as Appendix D.

Answers from 72 Cities and from 74 Companies were received in reply to these circular letters and a list of those Cities and Companies replying is a part of this report and may be found in Appendices "E" and "F" respectively.

The individual replies from the officers of the above mentioned Cities show that some were in favor of T-rail while others were against it; those that were against the use of T-rail stated that they had experienced trouble with the use of the ordinary section in paved streets as it was alleged the pavement could not be held in position on account of the depth of the rail; where high T-rail is used there has been no trouble experienced.

During the present year the City of Cleveland has ordered the use of T-rail in its paved streets and some 1,100 tons of Lorain Steel Company section 95–400 have been ordered for this purpose and work which has been finished has given much satisfaction to the city authorities.

REVISION OF THE RULES AND REGULATIONS FOR THE GOVERNMENT OF EMPLOYES OF THE WAY DEPARTMENT

The rules referred to in this report are those which were submitted by the 1911 Committee on Way Matters and in conformity with the recommendations of that Committee, circular letters were sent out by the Secretary to all Member Companies under date of April 6, 1912, calling attention to these rules and asking for suggestions as

to changes. There have been but few replies received, and for the most part they stated that the Rules had not been adopted. As these rules have been before the Member Companies but a short time, your Committee considers it inadvisable to undertake the revision this year, believing that the subject can be more intelligently and satisfactorily handled in Committee after some actual experience has been had by members of your Association in the use of these or similar rules or excerpts therefrom, thereby giving evidence that rules of this description are considered necessary and which in addition will furnish practical data upon which the Committee can work.

Your Committee therefore recommends that this subject be continued and be made a part of the work assigned to the 1912 Committee.

RECOMMENDATIONS

Your Committee recommends for adoption as "Standard" the following :—

1. Nine-Inch Girder-Grooved Rail, as shown in Fig. 1.
2. Seven-Inch Girder-Grooved Rail, as shown in Fig. 2.
3. Nine-Inch Girder-Guard Rail, as shown in Fig. 3.
4. Seven-Inch Girder-Guard Rail, as shown in Fig. 4.

The following are recommended for adoption as "Recommended Practice" by your Committee :—

1. Design for Joint Plates for Nine-Inch Girder-Grooved and Girder-Guard Rail, as shown in Fig. 5.
2. Design for Joint Plates for Seven-Inch Girder-Grooved and Girder-Guard Rail, as shown in Fig. 6.
3. The Revised Standard Specifications for Open-Hearth Girder and High T-Rails, as shown in Appendix B.

Respectfully submitted,

J. M. Larned, *Chairman.*
C. S. Kimball, *Vice-Chairman.*
C. L. Crabbs,
R. F. Kelker,
H. F. Merker,
B. E. Tilton,
C. H. Clark,
E. H. Berry,
C. W. Gennett, Jr.
*F. G. Simmons,
Committee on Way Matters.

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* Resigned March, 1912.

APPENDIX A

PROPOSED SPECIFICATIONS FOR ROLLED STEEL JOINTS FOR GIRDER, HIGH TEE, OR STANDARD T-RAILS

Rolled Steel Joints shall be either Grade "A" or Grade "B" as particularly specified at the time of ordering.

PHYSICAL PROPERTIES:

1. Test pieces cut from finished joints selected at random by the inspector, must show:

	"GRADE A"	"GRADE B"
Elastic Limit, lb. per sq. in.	½ Ult. Strength	½ Ult. Strength
Ultimate strength lb. per sq. in.	54–64,000	85–115,000
Elongation in 8 in.	25 per cent	10 per cent
Cold Bending Test without sign of fracture.	Flat on itself	To angle of 45 deg.

CHEMICAL PROPERTIES:

2. For the purpose of record, whenever possible manufacturers shall furnish an analysis of each heat from which the joints have been made.

WORKMANSHIP:

3. The punching and notching of joints must be accurate in every respect to drawing and dimensions furnished.

Grade "A" joints may be punched and notched cold.

Grade "B" joints must be punched and notched hot and pains taken not to destroy the integrity of the metal in any way.

FINISH:

4. All joints shall be smoothly rolled and true to templet. The name of the maker and year manufactured shall be rolled in raised letters on the side of the joint. The joints shall be sheared accurately to length and be free from mechanical defects, cracks, seams, flaws, fins, and on the whole, finished in a first-class workmanlike manner. They shall be a perfect fit to the rails for which they are intended.

INSPECTION:

5. The inspector, representing the purchaser, shall have free access to the works of the manufacturer at all times while this contract is being executed and shall have all reasonable facilities afforded him that the joints are being furnished in accordance with the contract.

APPEN

REVISED SPECIFICATIONS FOR OPEN

Report showing the results of the consideration and discussion by ing Materials, of the specifications of the American Electric Railway

Meetings were held October 10, 1911, at Atlantic City, and January mittee) representing the American Electric Railway Engineering

Also of the result of the discussion by Committee A-1 of the February 24, 1912. Messrs. Larned and Gennett representing the

Also, as amended and accepted by the American Society For Test- York, and as adopted by letter ballot of the Society and referred to

AMERICAN ELECTRIC RAILWAY SPECIFICATIONS	REMARKS
GENERAL.	
1. The entire process of manufacture and testing shall be in accordance with the best standard practice, and special attention shall be given to the following specifications:	
INGOTS.	
2. (*a*) A test ingot shall be cast, while each heat is being poured, from steel going into the middle of the heat.	
2. (*b*) "Bled" ingots. No ingot shall be used from the interior of which the liquid steel has been permitted to escape.	As "bled" is a well understood term, it was decided to shorten this paragraph.
2. (*c*) Badly teemed heats. No ingot shall be used from a heat poured without the control of the operator.	One paragraph (c) substituted for old paragraphs (c), (d) and (e) as old paragraph (c) is considered too indefinite and old paragraph (d) superfluous, the universal practice is to keep ingots in a vertical position and old paragraph (e) first sentence, unnecessary, as any lack of care would show and cause rejection under second sentence.
2. (*d*) Ingots shall be kept in a vertical position until ready to be rolled, or until the metal in the interior has had time to solidify.	
2. (*e*) Care shall be taken to avoid the burning of the steel while in the soaking pits and in reheating of the cold ingots. The ingots or blooms shall be discarded when the effects of injurious treatment show when rolled.	
CHEMICAL COMPOSITION.	
4. The steel of which the rails are rolled shall conform to the following limits in chemical composition: Carbon desired..... .68 limits .60—.75 Manganese desired... .80 limits .60—.90 Silicon, not over..... .20 Phosphorus, not over. .04	Decided to make this Section 3 instead of 4 as it should precede "Analysis." It was thought best also in consideration of the fact that a very hard rail is coming more generally into use, to specify two classes, leaving it with the purchaser to contract for the class he may desire to use. There was some discussion as to the "note," it being suggested that this should be mandatory instead of permissory, it also being held that in its present form it is not definite as to the party permitted.
Note: An increase of 0.035 per cent. carbon above the upper limit of this specification will be permitted for a decrease of each 0.01 per cent. of phosphorus below 0.04 per cent.	The paragraph in the recent American Railway Engineering Association specification replacing the above note was read, and it was finally decided to eliminate this note, there being no objections recorded by any of the parties interested.

DIX B

HEARTH GIRDER AND HIGH T-RAILS

Subcommittee 1 of Committee A-1 of the American Society for Test-
Engineering Association for Open-Hearth Girder and High T-Rails.
11, 1912, at Philadelphia. Messrs. Larned and Voynow (of 1911 Com-
Association.
American Society For Testing Materials at its meeting in New York,
American Electric Railway Engineering Association.
ing Materials at its annual meeting held March 27th and 28th at New
its Committee on Form.

REVISED SPECIFICATIONS

GENERAL:

1. The steel shall be made by the open-hearth process. The entire process of manufacture and testing shall be in accordance with the best standard practice, and special attention shall be given to the following specifications:

INGOTS:

2. (*a*) A test ingot shall be cast, while each melt is being poured, from steel from the middle of the melt.

2. (*b*) No bled ingot shall be used.

2. (*c*) Ingots or blooms which show the effects of injurious treatment shall be discarded.

CHEMICAL COMPOSITION:

3. The steel of which the rails are rolled shall conform to either of the following limits in chemical composition as may be called for in the contract:

	CLASS A	CLASS B
Carbon per cent	0.60 to 0.75	0.70 to 0.85
Manganese per cent	0.60 to 0.90	0.60 to 0.90
Silicon per cent., not over	0.20	0.20
Phosphorus per cent., not over	0.04	0.04

SPECIFICATIONS —(Continued)	REMARKS —(Continued)
ANALYSES.	
3. (*a*) The maker shall furnish the railway inspector daily with the chemical analysis for each heat, covering the elements specified under Section 4 hereof.	
3. (*b*) Each analysis shall be made from drillings taken from the test ingot at not less than ¼ in. beneath the surface thereof.	Adopted without change except as to depth below surface at which borings are to be taken. It was held that this depth should be made ⅛ in. instead of ¼ in. to conform with present practice of casting test ingots.
3. (*c*) These analyses may be checked from time to time by the railway company's chemist, and the maker shall furnish, on request of the inspector, a portion of the test ingot or drillings therefrom for check analysis.	
DISCARD.	
5. (*a*) Sufficient material shall be discarded from the top of the ingot to insure sound rails.	Originally adopted without change, but as it was subsequently decided to eliminate paragraph (c) of Article 20, it was decided to insert, at the end of paragraph (a) of Article 5, a sentence defining what should be done with piped rails.
5. (*b*) All metal from the top of the ingot, whether cut from bloom or rail, is the top discard.	
ROLLING.	
6. (*a*) The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the head of the rails shall not exceed the following as measured on the Fahrenheit scale: For rails weighing 100 lb. and upwards, 1900 deg. For rails weighing less than 100 lb., 1700 deg. 6. (*b*) The bars shall not be held for the purpose of reducing their temperature, nor shall any artificial means of cooling them be used between the leading and finishing passes, nor after they leave the finishing pass.	It was decided to cut out this section owing to the difficulty of measuring the temperature satisfactorily, and on account of the lack of temperature data or of data to show that the difference in temperature between which girder rail can be rolled affects the quality of the finished product. There was no objection made to the elimination of this article by the representatives of the American Electric Railway Engineering Association as it was remembered that at the time these specifications were considered and discussed by the Association, some considerable objection was made to this section.
BRANDING.	
7. The name of the maker, the letters "O.H." the weight of the rail, the section number and the month and year of manufacture shall be rolled in raised letters and figures on the side of the web, and the heat number shall be plainly shown on each rail where it will not be covered subsequently by the splice bars.	The sequence made to conform to general practice.
STRAIGHTENING.	
8. (*a*) Rails on the hot beds shall be protected from water or snow, and shall be carefully manipulated to minimize cold straightening.	

REVISED SPECIFICATIONS —(Continued)

ANALYSES:

4. (*a*) The maker shall furnish the railway inspector daily, prior to shipment, with the chemical analysis for each melt, covering the elements specified under Section 3.

4. (*b*) Each analysis shall be made from drillings taken from the test ingot at not less than ⅛ in. beneath the surface.

4 (*c*) These analyses may be checked from time to time by the railway company's chemist, and the maker shall furnish on request of the inspector, a portion of the test ingot or drillings therefrom for check analysis.

DISCARD:

5. (*a*) Sufficient material shall be discarded from the top of the ingot to obtain sound rails. Where the finished rails show piping they may be cut to shorter lengths until all evidence of this is removed.

5. (*b*) All metal from the top of the ingot, whether cut from bloom or rail, is the top discard.

BRANDING:

6. The letters "O. H.," the weight of the rail, the section number, the name of the maker and the year and month of manufacture shall be rolled in raised letters and figures on the side of the web, and the melt number shall be plainly shown on each rail where it will not be covered subsequently by the splice bars.

STRAIGHTENING:

7. (*a*) Rails on the hot beds shall be protected from water or snow, and shall be carefully manipulated to minimize cold straightening.

SPECIFICATIONS —(Continued)	REMARKS —(Continued)
STRAIGHTENING — (*Continued*). 8. (*b*) The distance between the rail supports in the cold-straightening presses shall not be less than forty-two (42) inches. The gag shall have rounded corners to avoid injury to the rail.	Attention was called to the necessity in some cases when straightening rails near the ends, of reducing the distance between supports. This practice being very generally permitted, should be covered.
8. (*c*) Any rail injured in cold-straightening, or showing gag marks therefrom, shall be rejected. 8. (*d*) "Lumpy" — that is, short kinked or wavy — rails shall be rejected.	
FINISH. 9. (*a*) Rails must be free from mechanical defects and flaws. They shall be smooth on the head, straight in line and surface without any twists, waves or kinks, particular attention being given to having the ends without kinks or drop. They shall have the ends square laterally and vertically, but the base may be undercut 1/32 in. 9. (*b*) All burrs or flow caused by drilling or sawing must be carefully removed.	First sentence eliminated as defects and flaws are permitted under the specifications in Article 15 and 16 defining 1st and 2nd quality rail, and this sentence is practically covered under Section 15 — "No. 1 rails." The milling of the ends of the rails omitted from original specifications is very properly inserted here.
DRILLING AND PUNCHING. 10. Circular holes for splice bars and bonds shall be drilled and for tie rods punched, to conform accurately in every respect to the drawing and dimensions furnished by the purchaser.	Holes are for joint bolts and not for splice bars. Voynow stated that he had found a number of cases where .75 to .90 carbon rails with welded joints had broken through a punched tie rod hole near the center of the rail. Most of the Committee thought punching undesirable in high carbon steel.
SECTION. 11. (*a*) The section shall be..... .....as shown in detail upon the attached plan and the cold templet of the manufacturer must accurately conform to the specified section, and must at all times be maintained perfect.	
11. (*b*) The section of the rail must conform as accurately as possible with the templet and any variation therefrom shall be within the following limits: Height, 1/16 in. under, 1/32 in. over. Overall width of head and tram ⅛ in. under or over, provided that said variation will not affect the gage line by more than 1/32 in. Width of base ⅛ in. under or over.	Attention was called to the fact that the permissible variation in width of base might become objectionable to the purchasers where track is built upon concrete beams, pedestals or yokes or upon steel ties, or where tie plates are attached to the tie previous to installation. It was decided to confine the permissible variation in width of base to a variation under, no variation over being permitted. It was claimed by the manufacturers that the permissible variation for very wide flanges should be somewhat more than ⅛ in. The clause covering variation in width of base was therefore made to read as shown, with the understanding that the attention of Committee A-1 be called to the necessity of collecting data as to variation in width of base under present mill practice and with reference especially to reducing the permissible variation in the width of the base between the outer edge and the gauge line.

REVISED SPECIFICATIONS —(Continued)

STRAIGHTENING — *(Continued)*:

7. (*b*) The distance between the rail supports in the cold-straightening presses shall not be less than forty-two (42) inches except as may be necessary near the ends of rails. The gag shall have rounded corners to avoid injury to the rail.

7. (*c*) Any rail injured in cold-straightening, or showing gag marks therefrom, shall be rejected.

7. (*d*) "Lumpy"—that is, short kinked or wavy—rails shall be rejected.

FINISH:

8. (*a*) Rails shall be smooth on the head, straight in line and surface without any twists, waves or kinks, particular attention being given to having the ends without kinks or drop. The ends shall be milled square laterally and vertically, but the base may be undercut 1/32 in.

8. (*b*) All burrs or flow caused by drilling or sawing shall be carefully removed.

DRILLING AND PUNCHING:

9. Circular holes for joint bolts, bonds and tie rods shall be drilled to conform accurately in every respect to the drawing and dimensions furnished by the purchaser. In Class A rail, however, the tie rod holes may be punched.

SECTION:

10. (*a*) The section shall be.....as shown in detail upon the attached plan and the cold templet of the manufacturer shall accurately conform to the specified section and shall at all times be maintained perfect.

10. (*b*) The section of the rail shall conform as accurately as possible to the templet and any variation therefrom shall be within the following limits:

Height, 1/64 in. under, 1/32 in. over.

Overall width of head and tram ⅛ in. under or over, provided that said variation will not affect the gauge line by more than 1/32 in.

Width of base ⅛ in. under, except that in flanges 6½ in. wide, 3/16 in., and flanges 7 in. wide, where ¼ in. variation will be allowed. When necessary on account of form of track construction, and notice to that effect is given to the manufacturers, special care shall be taken to maintain the proper position of gauge line with respect to outer edge of base.

SPECIFICATIONS —(Continued)	REMARKS —(Continued)
SECTION — (*Continued*).	
11. (*c*) No variation will be allowed in the dimensions affecting the fit of the splice bars.	It was held that some variation must occur and this paragraph was changed.
11. (*d*) The base of the rail shall be rolled to a true plane, at right angles to the web. A convexity of the base of 1/32 in. being permitted.	Wording revised because it was held that the term " true plane " is in opposition to the allowable convexity as specified.
WEIGHT.	
12. (*a*) The weight of the rails per yard as specified in the order shall be maintained as nearly as possible, after complying with Section 11, and the aggregate of the order shall not vary more than one-half of 1 per cent. from the specified weight.	
12. (*b*) Actual weights will be paid for.	
LENGTH.	
13. (*a*) The lengths of rails at a temperature of 60 deg. Fahr. shall be sixty (60) feet, and sixty-two (62) feet for those sections in which the weight per yard will permit.	These two paragraphs covered in one, the comma between 60 feet and 62 feet omitted making what follows apply to both lengths, and the words " unless otherwise specified " inserted. It was also held that not only short rails, but all rails should be paired as to length before shipment.
13. (*b*) Ten per cent. of the entire order will be accepted in shorter lengths, varying by even feet down to forty (40) feet, and shall be paired as to lengths before shipment.	
13. (*c*) A maximum variation of ¼ in. over or under the specified lengths will be allowed.	
DROP-TESTING MACHINE.	
14. The drop-testing machine shall be of the type that is recommended by the American Railway Engineering and Maintenance of Way Association.	Correct name of Association used.
DROP TESTS	
15. (*a*) Three test pieces shall be selected by the inspector from each heat, and they shall be in each case taken from the crop end of the rails rolled from the top of the ingot and selected at approximately equal intervals from the heat as poured. They shall not be less than four (4) feet nor more than six (6) feet in length.	It seemed unnecessary to compel the manufacturer to cut three test pieces, making three short rails, when only two specimens are generally used. Also as the inspector selects the pieces, it seemed unnecessary to specify selection at equal intervals.
15. (*b*) The test rails shall be placed head upwards on the support and shall be subjected to an impact test under a free falling weight of 2,000 lb. Height of drop for rails weighing 100	The distance between supports given, as this can be varied on Standard machine. Weight tup, however, is fixed at 2,000 lb., but the Committee decided to insert this parenthetically for the

REVISED SPECIFICATIONS —(Continued)

SECTION —(*Continued*):

10 (*c*) No variation will be allowed which will affect the fit of the splice bars.

10 (*d*) The base of the rail shall be at right angles to the web and shall not have a convexity greater than 1/32 in.

WEIGHT:

11. (*a*) The weight of the rails per yard as specified in the order shall be maintained as nearly as possible after complying with Paragraph 10, and the aggregate of the order shall not vary more than one-half of one per cent. from the specified weight.

11 (*b*) Payments shall be based upon actual weights.

LENGTH:

12. (*a*) The lengths of rails at a temperature of 60 deg. Fahr. shall be sixty (60) and sixty-two (62) feet, for those sections in which the weight per yard will permit, unless otherwise specified. Ten per cent. of the entire order will be accepted in shorter lengths, varying by even feet down to forty (40) feet. All rails shall be paired as to length before shipment.

12. (*b*) A maximum variation of ¼ in. over and under the specified lengths will be removed.

DROP-TESTING MACHINE:

13. The drop-testing machine shall be of the type recommended by the American Railway Engineering Association.

DROP TESTS:

14. (*a*) Three rails from the top of ingots shall be selected by the inspector from each heat, from two of which a test specimen not less than four or more than six feet in length shall be cut.

14. (*b*) The test specimens shall be placed head upwards on supports three feet apart and shall be subjected to the specified fall of the standard tup (2000 lb.), as follows:

SPECIFICATIONS —(Continued)	REMARKS —(Continued)
DROP TEST — (*Continued*), lb. per yard and upward fifteen (15) feet. Height of drop for rails weighing less than 100 lb. per yard thirteen (13) feet.	sake of convenience. After discussion, and objection on the part of some of the members, it was decided to leave the height of drop as at present specified for Class A rails, and to reduce it to 12 and 10 feet for the high carbon Class B rails. Further discussion brought out the fact that the Subcommitee was very generally of the opinion, as hardness is more desirable than great resistance to breakage in girder rails that a more satisfactory physical test could possibly be set up for such rails than the drop test. A bending and a ball impression test having been suggested, it was decided to recommend, to Committee A-1 that a special Committee be appointed to collect data and make tests to determine whether other and more satisfactory physical tests can be substituted for the drop test, and it having been decided to retain the drop test for the present, it was thought desirable that the depth of rail as well as the weight should be considered in the height of the drop.
15. (*c*) The temperature of the test pieces, when tested, shall not be less than 60 deg. Fahr. or greater than 120 deg. Fahr.	
15. (*d*) The testing shall proceed concurrently with the operation of the mill.	
15. (*e*) Rail under drop test shall be considered as having failed when fractured or showing indications of the same.	The Committee thought this provision unnecessary as there is never any question whether a rail has failed and the clause was therefore eliminated. Changed to conform with revised (a) of this section.
15. (*f*) Two drop tests shall be made of the test rails from each heat. Should both rails withstand the test all the rails from the heat which they represent shall be accepted. Should one of the two test rails fail under the test the third rail selected shall be tested, and if two of three rails fail all rails from the heat which they represent shall be rejected.	
15. (*g*) The report of the drop test should state the atmosphere temperature at the time the tests were made.	
NO. 1 RAILS. 16. No. 1 rails shall be free from defects and flaws of all kinds.	It was suggested that these two sections be changed so as to have Section 15 cover more clearly what would constitute a No. 1 rail and as to adapt Section 16 to girder rail practice, the section having been largely drawn from T-rail specifications. After discussion it was found difficult to specify definitely what imperfections would be permitted in a No. 1 rail, and it was therefore decided to insert the word "injurious" before "defects" and to
NO. 2 RAILS. 17. (*a*) Rails which by reason of surface or other imperfections are not classed as No. 1 rails will be considered No. 2 rails, providing they do not in the judgment of the inspector contain imperfections in such number and of such character in any individual rail as to render such rail unfit for	

REVISED SPECIFICATIONS —(Continued)

DROP TESTS —(*Continued*):

	Fall in Feet	
	Class A	*Class B*
Rails weighing over 100 lb. per yard. and over 7 in. in depth	15	12
Rails weighing 100 lb. or less per yd. or 7 in. or less in depth	13	10

14. (*c*) The temperature of the test specimens, when tested, shall not be less than 60 deg. Fahr. nor greater than 120 deg. Fahr.

14. (*d*) The testing shall proceed concurrently with the operation of the mill.

14. (*e*) Drop tests shall be made of the two test specimens from each melt. Should both specimens withstand the test, all the rails from the melt which they represent shall be accepted. Should one of the two test specimens fail, the third rail selected shall be tested and if two of three specimens fail, all rails from the melt which they represent shall be rejected.

14. (*f*) The report of the drop tests shall state the atmospheric temperature at the time the tests were made.

NUMBER 1 RAILS:

15. No. 1 rails shall be free from injurious defects and flaws of all kinds.

NUMBER 2 RAILS:

16. (*a*) Rails which are rough on the head or which by reason of surface or other imperfections are not classed as No. 1 rails will be considered No. 2 rails, providing they do not in the judgment of the

SPECIFICATIONS —(Continued)	**REMARKS —(Continued)**
NUMBER 2 RAILS— (*Continued*). recognized No. 2 uses, and providing such rails comply with the requirements of Section 11 of this specification.	make no further change in Section 15. Attention was called to the necessity of having rails smooth on the head as called for under Section 8(a), as roughness and scale has a tendency to produce corrugations. It was decided under Section 16(a) to call attention to this point by the insertion of a few words as shown.
17. (*b*) Rails shall not be accepted as No. 2 rails having flaws of more than ¼ in. in depth in the head or more than ½ in. in depth in the base.	
17. (*c*) No. 2 rails will be accepted to the extent of 10 per cent. by weight of the entire order.	
DISTINGUISHING MARKS.	
18. No. 1 rails (short lengths)—Both ends of all short-length No. 1 rails shall be painted green.	
No. 2 rails (all lengths) — Both ends of all No. 2 rails shall be painted white and shall have two heavy center punch marks on the web of the rail at such a distance from both ends that they will not be covered by the joint plates.	
HANDLING AND LOADING.	
19. (*a*) All rails must be loaded in the presence of the inspector, and shall be handled in such a manner as not to bruise their flanges or cause other injuries.	
19. (*b*) Rails of each class must be placed together in loading.	
19. (*c*) Due notice must be given the inspectors of the time of loading so they may be present.	Agreed to be superfluous.
INSPECTION.	
20. (*a*) The inspectors, representing the purchaser, shall have free access to the works of the manufacturer at all times during the execution of any contract under this specification, and shall have all reasonable facilities afforded to satisfy themselves that the rails are being made in accordance with this specification.	The Committee was not satisfied with the wording and thought the repetition in some of the clauses unnecessary, the same having been covered elsewhere in the specifications. It was decided to cover (a) and (b) of this section in one clause as shown.
20. (*b*) All tests and inspections shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.	
20. (*c*) The inspector shall have authority to reject rails from heats, the test pieces of which have failed, or from rails not in accordance with Section 11, or from badly poured heats, or from "Bled" ingots or any other causes not in accordance with good mill practice.	The first paragraph of this clause being a repetition was considered superfluous and eliminated.

REVISED SPECIFICATIONS —(Continued)

NUMBER 2 RAILS — (*Continued*):

inspector contain imperfections in such number and of such character in any individual rail as to render such rail unfit for recognized No. 2 rail uses, and providing such rails meet the requirements of Paragraph 10 of these specifications.

16. (*b*) Rails shall not be accepted as No. 2 rails having flaws of more than ¼ in. in depth in the head or more than ½ in. in depth in the base.

16. (*c*) No. 2 rails will be accepted to the extent of 10 per cent. by weight of the entire order.

DISTINGUISHING MARKS:

17. Both ends of all short-length No. 1 rails shall be painted green. Both ends of all No. 2 rails shall be painted white and shall have two heavy center-punch marks on the web of the rail at such a distance from both ends that they will not be covered by the joint plates.

HANDLING AND LOADING:

18. (*a*) All rails shall be loaded in the presence of the inspector, and shall be handled in such a manner as not to bruise their flanges or cause other injuries.

18. (*b*) Rails of each class shall be placed together in loading.

INSPECTION:

19. The inspector representing the purchaser shall have free entry to the works of the manufacturer at all times while his contract is being executed, and shall have all reasonable facilities afforded him by the manufacturer to satisfy him that the rails are being made in accordance with the terms of the contract. All tests and inspections shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the mill.

SPECIFICATIONS —(Continued)	**REMARKS —(Continued)**
INSPECTION— (*Continued*).	
Rails for insufficiently sheared blooms shall be accepted if they are not shorter than the minimum lengths, when properly cut, and otherwise conform to this specification.	
Rails which show "pipes" should be cut to the shortest permissible length, and if "pipe" is not visible they shall be accepted as No. 2 rails.	The second paragraph of this clause was considered unnecessary.
All lumpy rails shall be rejected.	The third paragraph of this clause as to piped rails, the Committee held that there was no necessity for cutting a piped rail any further than is necessary to assure the inspector that the pipe is removed, and no necessity for making such a rail a No. 2 after the pipe had been removed, and it was decided that this paragraph should be covered somewhat differently, and inserted under Section 5 (a) which see.
Rails shall be rejected if imperfectly drilled, chipped or filed, but shall be accepted if properly refinished.	The fourth paragraph, "lumpy rails" having been covered under Section 7 (d) was considered superfluous at this point. The fifth paragraph was considered unnecessary as the substance was sufficiently covered under Section 8 (b).

REVISED SPECIFICATIONS —(Continued)

APPENDIX C

COPY OF CIRCULAR LETTER SENT TO 140 CITIES

DEAR SIR: The undersigned is Chairman of the Standing Committee on Way Matters of the American Electric Railway Engineering Association, and is also Chairman of a Subcommittee to which has been entrusted particularly the investigation of the use of T-rails in government pavement on City Streets.

The purpose of this investigation is to secure and prepare in statistical form all available information upon this subject, as the practice obtaining in different cities and different parts of the country is very dissimilar.

It would therefore be of great assistance to the work if we could secure from you some information as to the following matters:

1. Does the street railway company in your City use any T-rail in permanently paved streets?

2. Do your City ordinances permit such use?

3. Will you send an extract from any of your ordinances which designates the type of rail to be used under these conditions?

4. Will you furnish a brief statement as to your personal views relative to the use of a proper section of Shanghai T-rail in permanently paved streets?

I will be greatly obliged if you will forward me as promptly as consistent as much information as you feel willing to impart relative to the foregoing matters and would be very glad to inform you later as to the result of these investigations if you so desire.

Very truly yours,

FRED G. SIMMONS,
Chairman COMMITTEE ON WAY MATTERS.

APPENDIX D

COPY OF CIRCULAR SENT TO MEMBER COMPANIES

To Member Companies:

The Committee on Way Matters, in order to prepare its report to the 1912 Convention, requires the information called for in this Data Sheet. The value of Committee reports depends largely upon the extent to which the members co-operate in supplying information, and it is hoped therefore that the replies will be full and complete.

INFORMATION REQUIRED AS TO THE USE OF T-RAIL FOR TRACK CONSTRUCTION IN PAVED STREETS.

Data Sheet No. 89. New York, April 4, 1912

Company . . . .

City . . .. State . . ..

Total City Mileage Operated?.....

Total Mileage of track in Paved Streets.....
- a Stone or granite block....
- b Brick.....
- c Asphalt.....
- d Other pavements.....

Total Amount of T-Rail laid in Paved Streets.....
- a Stone or Granite Block....
- b Brick.....
- c Asphalt.....
- d Other pavements.....

Do you use a filler block next to the rail?.....

Section of Tee Rail used.....
- a.....Mileage.....
- b.....Mileage.....
- c.....Mileage.....

Type of joint used?.....

Kind of Tie used?.....

Kind of Ballast used?.....

Kind of track drainage used?.....

Average age of T-rail track laid in paved streets, if any?.....

Mileage of T-rail track laid in paved streets in 1911 if any?.....

Do you favor the use of Shanghai or other T-rail in City streets where Municipal or State Regulation will permit.....

Please state reasons.....

.....

.....

Have you made any effort to secure the substitution of T-rail for Girder or Grooved-Girder rail?.....

Has Girder or Grooved-Girder rail been substituted for T-rail?.....

Please forward to the Committee, blueprint showing your standard method of track construction in paved streets.....

Does not the use of T-rail tend to reduce delays incident to vehicular traffic along the tracks?.....

Signed.....

Title.....

NOTE.— This information blank is sent you in duplicate form. Please fill in the information asked for at your earliest convenience and return one copy to me at my office, 98th Street & Third Avenue, New York City.

Yours very truly,

NORMAN LITCHFIELD,
Secretary-Treasurer.

APPENDIX E

TABULATION OF REPLIES RECEIVED FROM CIRCULAR LETTER TO CITY OFFICIALS REGARDING RAIL IN PAVED STREETS

City	City official responding	Type of rail used	Remarks
ALABAMA:			
Birmingham...	City Engineer.....	Shanghai T.....	
CALIFORNIA:			
Los Angeles...	City Engineer.....	Girder.....	City ordinance passed Dec. 5, 1911 prohibits T-rail in paved streets.
San Francisco..	City Engineer.....	Girder-grooved..	Formerly used T-rail.
COLORADO:			
Colorado Spgs.	City Engineer.....	.....	Have no paved streets.
CONNECTICUT:			
Bridgeport....	City Engineer.....	T-rail.....	
Hartford.....	City Engineer.....	Girder.....	T-rail prohibited by contract with electric railway company.
New Haven...	City Engineer.....	Shanghai T.....	
DISTRICT OF COLUMBIA:			
Washington...	Assistant of Engineers Commission.	Grooved Trilby.	T-rail prohibited by Commissioners of the District of Columbia.
FLORIDA:			
Jacksonville...	Chief City Engineer.	T-rail.....	Now want grooved rail.
GEORGIA:			
Atlanta.....	Chief Engineer of Construction.	Grooved and T-rail.	
ILLINOIS:			
Peoria.....	City Engineer.....	Girder.....	No T-rail in city, but can be overruled.
Springfield....	City Engineer.....	Shanghai T.	
INDIANA:			
Evansville.....	City Engineer.....	Shanghai T.....	
Fort Wayne...	City Engineer.....	T-rail.....	
Indianapolis...	Chief Engineer....	T-rail.....	
IOWA:			
Davenport....	Commission of Public Works.	Shanghai T.....	Prior to 1907 T-rail was prohibited by ordinance.
KANSAS:			
Kansas City...	City Engineer.....	Girder.....	
KENTUCKY:			
Lexington.....	City Engineer.....	Shanghai T.....	
Louisville.....	Chief Engineer....	Girder-grooved..	
LOUISIANA:			
New Orleans...	Assistant City Engineer.	Girder.....	Used in all paved streets.
MAINE:			
Portland.....	City Engineer.....	Girder.....	Want to use T-rail; referred to general manager.
MARYLAND:			
Baltimore.....	City Engineer.....	Girder-grooved..	
MASSACHUSETTS:			
Boston.....	Chief Engineer....	Girder and T-rail	Mostly girder rail in paved streets.
Brockton.....	City Engineer.....	Girder.....	T-rail not prohibited by ordinance.
Cambridge....	City Engineer.....	Girder.....	No T-rail used.
Holyoke.....	City Engineer.....	Girder-grooved..	Formerly allowed T-rail.
Lawrence.....	City Engineer.....	Girder-grooved..	
Lynn.....	City Clerk—Street Commissioner.	.....	No information given.
New Bedford..	City Engineer.....	Girder-grooved..	City Engineer inclined to favor girder rail.
Springfield....	City Engineer.....	Girder.....	City Engineer inclined to favor T-rail in paving. None in use at present.
Worcester.....	City Engineer.....	Girder and T-rail	Very little T-rail used.

APPENDIX E — (Continued)

City	City official responding	Type of rail used	Remarks
MICHIGAN:			
Detroit	City Engineer	T-rail	
Grand Rapids	City Engineer	T-rail	
Saginaw	City Engineer	T-rail	
MINNESOTA:			
Duluth	City Engineer	Shanghai T	
Minneapolis	City Engineer	Shanghai T	
St. Paul	Commission of Public Works.	Shanghai T	
MISSOURI:			
St. Joseph	City Engineer	Shanghai T	Both girder and T-rail allowed
St. Louis	Chief Commissioner.	Girder and T-rail	T-rail not used entirely.
NEBRASKA:			
Lincoln	City Engineer	T-rail	
Omaha	City Engineer	Girder	
NEW JERSEY:			
Elizabeth	City Engineer	Girder	No T-rail used.
Paterson	City Engineer	Girder	
NEW YORK:			
Buffalo	Deputy, Engineer Commission.	Girder	No T-rail used.
Elmira	Assistant City Engineer.		Nothing special.
Rochester	City Engineer	Girder and T-rail	
Schenectady	City Engineer	T-rail	
Syracuse	City Engineer	Shanghai T	
Utica	Deputy City Engineer.	T-rail	
Yonkers	City Engineer	Girder	No T-rail used.
No. CAROLINA:			
Charlotte	City Engineer	Shanghai T	
OHIO:			
Cincinnati	Chief Engineer, Department of Public Service.	T-rail and girder	T-rail no longer allowed.
Cleveland	Chief Engineer, Department of Public Service.	Girder-grooved rail.	City authorities have now authorized use of T-Rails in Paved Streets.
Columbus	Chief Engineer, Department of Public Works.	Girder-grooved and T-rail.	T-rail prohibited by city ordinance, passed June 10, 1907.
OREGON:			
Portland	City Engineer	Girder-grooved and Shanghai T.	
PENNSYLVANIA:			
Harrisburg	City Engineer	Girder-grooved and Tram.	
Philadelphia	Chief Engineer and Surveyor.	Girder	No T-rail used in paved streets.
Reading	City Engineer	Girder	No T-rail used. City Engineer favors use of T-rail in paved streets.
Scranton	City Engineer	Shanghai T	
Wilkes-Barre	City Engineer	Girder and T-rail	T-rail only partly used.
York	City Engineer	Trilby-grooved-girder.	
RHODE ISLAND:			
Providence	City Engineer	Girder-grooved	No T-rail used, prohibited by city.
So. CAROLINA:			
Charleston	City Engineer	Girder-grooved and T-rail.	
TEXAS:			
Dallas	City and County Engineer.	Girder-grooved and T-rail.	
TENNESSEE:			
Knoxville	City Engineer	Girder-grooved and T-rail.	

APPENDIX E — (Concluded)

City	City official responding	Type of rail used	Remarks
UTAH:			
Salt Lake City.	City Engineer.....	Shanghai T.....	
VIRGINIA:			
Richmond.....	City Engineer.....	Girder-grooved	
WASHINGTON:			
Seattle.....	City Engineer.....	Shanghai T.....	
Spokane.....	City Engineer.....	T-rail.....	
Tacoma.....	City Engineer.....	Shanghai T.....	
WISCONSIN:			
Superior.....	City Engineer.....	T-rail.....	
HAWAII:			
Honolulu.....	City Engineer.....	Girder.....	City Engineer prefers T-rail for paved streets.

APPENDIX F

TABULATION OF INFORMATION RECEIVED FROM REPLIES TO DATA SHEET SENT TO MEMBER COMPANIES

Name of Company	City	Total city mileage operated	Total mileage of T-rails laid in paved streets	Average age of T-rails laid in paved streets
ALABAMA:				
Birmingham Light & Power Co.	Birmingham	52.16	5.70	15
Mobile Lt. & R. R. Co.	Mobile	116.77	16.4	9
CALIFORNIA:				
Los Angeles Ry. Corp.	Los Angeles	351.0	131.0	6 to 10 yrs
COLORADO:				
Arkansas Valley Ry. Lt. & Pwr. Co.	Pueblo	35.0	4.86	6
DISTRICT OF COLUMBIA:				
Washington Ry. & Elec. Co.	Washington	46.75	0.1	3
GEORGIA:				
Athens Ry. & Elec. Co.	Athens	9.3	3.5	6
Georgia Ry. & Power Co.	Atlanta	158.755	55.88	10
Savannah Electric Co.	Savannah	.....	32.45	8
ILLINOIS:				
Central Ill. Public Service Co.	Mattoon	3.0	3.0	7
E. St. Louis & Suburban Ry.	East St. Louis	44.55	2.33	2
Galesburg & Kewanee El. Ry. Co.	Kewanee	5.0	.....	5
INDIANA:				
Chicago, So. Bend & No. Ind. Ry.	South Bend	60.0	60.0	20
Indianapolis Trac. & Terminal Co.	Indianapolis	142.0	36.1	4
Muncie & Portland Trac. Co.	Portland	2.0	2.0	.....
IOWA:				
Des Moines City Railway Co.	Des Moines	85.07	14.07	.....
Mason City & Clear Lake R. R. Co.	Mason City	6.0	2.0	1–9
Waterloo, Cedar Falls & No. Ry. Co.	Waterloo	25.50	8.58	4
KANSAS:				
Kansas City-Western Ry. Co.	Leavenworth	18.07	14.0	4
MAINE:				
Rockland, Thomaston & Camden St. Ry. Co.	Rockland	22.5	1.0	19
MICHIGAN:				
Grand Rapids Railway Co.	Grand Rapids	63.7642	13.6255	4
Houghton County Traction Co.	Houghton	8.93	1.77	10
Menominee & Marinette Lt. & Tr. Co.	Menominee	19.23	4.55	5
Saginaw Bay City Ry. Co.	Saginaw	24.899	12.122	.....
MARYLAND:				
Cumberland & Westernport El. Ry.	Cumberland	1.75	0.189	.....
MINNESOTA:				
Twin City Rapid Transit Co.	Minneapolis	313.0	164.7	.....
MISSISSIPPI:				
Vicksburg Traction Co.	Vicksburg	10.0	3.85	2
MISSOURI:				
United Rys. Co. of St. Louis.	St. Louis	348.33	1.58	7
NEW JERSEY:				
Bridgeton & Millville Trac. Co.	Bridgeton	9.0	1.0	8
NEW YORK:				
Brooklyn Rapid Transit Co.	Brooklyn	392.385	8.916	.....
Fonda, Johnstown & Gloversville R. R. Co.	Gloversville	15.53	15.35	20
Hudson Valley Railway Co.	Glens Falls	7.16	3.16	4.5
Ithaca St. Ry. Co.	Ithaca	10.5	3.0	5
Kingston Consolidated Ry. Co.	Kingston	7.979	7.979	2
New York State Rys.	Rochester	139.44	9.15	3
Schenectady Railway Co.	Schenectady	39.291	3.421	3
Syracuse, Lake Shore & No. R. R.	Syracuse	21.3	8.75	4
Utica & Mohawk Valley Ry. Co.	Utica	66.426	21.346	6+

APPENDIX F — (Concluded)

Name of Company	City	Total city mileage operated	Total mileage of T-rails laid in paved streets	Average age of T-rails laid in paved streets
OHIO:				
Cleve., Painsville & East. Ry. Co..	Willoughby...	280.0	2.9	6
Cleveland Railway Co.....	Cleveland....	*	.....	..
Northern Ohio Trac. & Lt. Co....	Akron.....	215.0	6.0	...
Scioto Valley Traction Co.....	Columbus....	3.5	2.64	..
PENNSYLVANIA:				
Altoona & Logan Valley El. Ry...	Altoona.....	21.0	1.42	6
Buffalo & Lake Erie Trac. Co.....	Erie.....	73.32	26.83	14
Phila. & West Chester Trac. Co...	Upper Darby.	.....	0.84	6
Pittsburgh Railways Co.....	Pittsburgh....	473.7603	2.776	.....
Scranton Rys. Co.....	Scranton.....	39.555	30.57	2.39
Valley Traction Co.....	Lemoyne.....	.....	.06	... ..
RHODE ISLAND:				
Rhode Island Co.....	Providence...	162.41	39.63	.....
TENNESSEE:				
Chattanooga Ry. & Lt. Co.....	Chattanooga..	25.0	13.0	7
Johnson City Trac. Co.....	Johnson City.	5.5	2.25	2
Knoxville Ry. & Lt. Co.....	Knoxville....	29.75	6.3	5
TEXAS:				
Austin Street Ry. Co.....	Austin.....	18.7	2.827	5
Texarkana Gas & Elec. Co.....	Texarkana....	11.0	12.0	10
VIRGINIA:				
Roanoke Ry. & Elec. Co.....	Roanoke.....	15.0	15.0	1 5
WASHINGTON:				
Everett Ry. Lt. & Water Co.....	Everett.....	15.45	15.45	.....
Olympia Lt. & Pr. Co.....	Olympia.....	5.00	1.47	2
Whatcom County Ry. & Lt. Co....	Bellingham...	24.0	10.75	.....
WEST VIRGINIA:				
Appalachian Power Co.....	Bluefield.....	5.44	2.4	4
Fairmont & Clarksburg Trac. Co..	Fairmont.....	16.36	6.1	7
WISCONSIN:				
Duluth Street Railway Co.....	Superior.....	80.43	77.82	12
Milwaukee El. Ry. & Lt. Co.....	Milwaukee....	143.87	143.87	10
CANADA:				
Halifax Elec. Tram. Co. L't'd.....	Halifax.....	14.50	14.50	7
Ottawa Elec. Ry. Co.....	Ottawa.....	31.57	19.0	1-10
MEXICO:				
Mexico Tramways Co.....	Mexico City..	100.52	24.743	12

* City authorities have now authorized T-rail in paved streets.

PRESIDENT ACKERMAN:— The first is the subject of rail sections and joints for the same; the rail sections include the straight line rail and the special track work rail, girder and guard sections. Some of the engineers of the manufacturing companies are here and as the objections to the proposed rail sections come from them, I would like these gentlemen to enter into the discussion. We will be glad to hear from Mr. C. A. Alden, of the Pennsylvania Steel Company.

Discussion of Report of Committee on Way Matters

MR. ALDEN:— I have been requested by the Chairman of the Committee on Way Matters to comment on the rail sections submitted, especially the guard rails.

The dimensions of the groove in the guard rail can be determined theoretically in several ways provided the assumptions necessarily made are found to exist in practice, theory should agree with practice.

The assumption on which the proposed section is designed will rarely exist. Ordinarily cars run upon any system of widely different wheel bases, instead of but one, as assumed, and wheel flanges are produced by wear, both of different sizes and different shapes than the standard of the system in question.

In the report of the Engineering Association for 1909, Vol. I, pages 72 to 79 inclusive will be found a discussion of the gauges and guard-rail grooves on curves, clearly showing that for the conditions met with in service, it is theoretically necessary to widen the gauge on curves, and also the width of guard rail grooves, and this necessity is also proven by practice.

All these conditions were taken into consideration by the speaker in designing the groove in P. S. C.-283. This rail is still believed to be the correct dimensions for A. E. R. E. A. standard flanges and to require the minimum amount of planing for conditions as they exist. The speaker therefore believes that the width of groove given as 1 9/16 in. should be increased to 1 11/16 in.; the angle given as 65 deg. should be increased to 70 deg. and the gauge side angle given as 3 deg. 22 min. 38 sec. to 10 deg.

In regard to the dimensions of the guard necessary to resist the strains of guiding wheels around the curve, resisting abrasion, and providing material so that groove may be enlarged when required by conditions. The Pennsylvania Steel Company's first guard rail, designed some twenty years ago, had a thickness of bottom of groove of 5/8 in. and a thickness of guard of 3/4 in. Progressing through various sections these dimensions were increased as ex-

perience proved their necessity, until the last section designed by them had a thickness at bottom of groove of 29/32 in. and a thickness of guard of 1¼ in. The proposed section has a thickness at bottom of groove of about 11/16 in. and a thickness of guard of less than 1 in. I think our experience has proved these dimensions to be insufficient and that they should be increased to at least ⅞ and 1¼ in. respectively.

It might be well at this time to point to the fact that there are in existence today guard rails rolled by the Pennsylvania Steel Company, their section 151-283, and a nearly identical section by the Lorain Steel Company, their 150-441, both admirably suited to the A. E. R. E. A. Standard wheel flanges. Probably arrangements could be made to bring these sections into exact agreement as to the shape of the tread to meet the views of your committee, and thus provide a guard rail suiting A. E. R. E. A. conditions without adding other rail sections to the lengthening list. Suitable "mechanical" joints for these sections are also in existence, at least as good as those proposed, as well as patented joints and by taking these as a basis and designing a straight track rail therefrom, a really effective standard might be very shortly evolved and a practical advance made towards a standard which would be used in practice instead of simply being illustrated in the proceedings.

This procedure would enable the tram of the rail to be strengthened at its weakest point. The necessity for this was pointed out at the 1911 Convention. It would also involve the abandonment of the tapered web, which at best is pure theory, and should be tested in practice before embodiment in an Association Standard or Recommended Practice.

The base of the rail would be reduced to 6 in. instead of 6½ in., but this has been ample for service and removes some serious rolling difficulties. The top of the head can be shaped to suit the views of the users of the rails who are better fitted to pass on this question than the manufacturer. The method proposed by the Committee of evolving a 7-in. rail from a 9-in. rail seems logical and I can suggest no change in same.

MR. ANGERER:— Regarding criticisms and suggestions of

the proposed standard girder grooved and guard rails, as presented in the Way Committee report, one is loath to venture any criticism upon the results of so much thought and such a thorough investigation as your Committee has given to the subject. Furthermore, I believe that the sections as proposed would cover the requirements of such a large number of railway companies, and standard sections of this character are such a crying need, provided they do not simply remain standard on paper, but are adopted for actual general use by a majority of the railway companies, that I would rather see no further improvement attempted than have the consideration of such, delay their final adoption.

The general outline and dimensions of the various parts of the new girder sections for straight track were so thoroughly discussed last year that I can add nothing, except that I would again like to call attention to the rather thin metal in the tram part. Since last year's meeting at Atlantic City, I have had a number of plaster casts taken of rails of a similar top contour, that have been in service for some time, and the sketch marked Exhibit A herewith

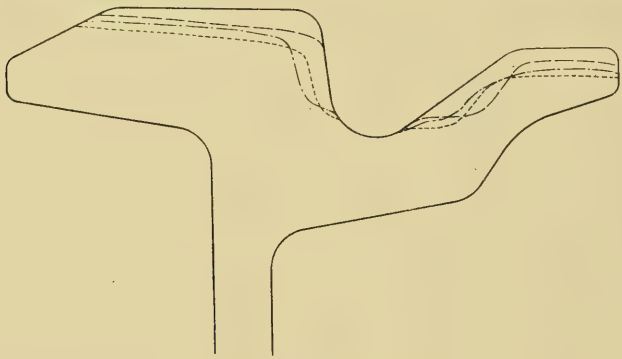


EXHIBIT A

shows some of the wear lines, produced partly by the "nosing" of cars or bad wheel gauge or track gauge, and partly by the vehicular traffic. The wheel flanges of the cars using this track were 11/16 in. deep and rather narrow.

Wheel flanges of the Association Standard "A", ⅞ in. deep and correspondingly thicker, would, I should say, deepen these wear lines, and making the correction, I have developed the wear line shown on sketch Exhibit B, at a

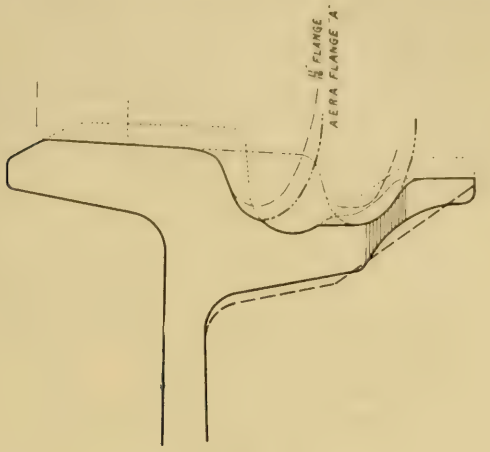


Exhibit B

point where the tread at or near the gauge line is worn down ⅜ in. This shows that the thickness of metal that would then be left at the thinnest part of the tram, where it is hollowed out underneath the 37 deg. slope by the radius of 1 23/64 in., would be only 3/16 in., and I believe that long before it reached that point the heavy vehicular traffic coming on top of the extreme end of the tram part would bend the tram down and possibly break it off.

I am aware that most similar sections which are at present rolled are also similarly hollowed out and do not give any more metal further down at that point, but I do not know that any such rails have been traveled over long enough by cars with ⅞ in. flanges to either prove or disapprove my argument, but it seems to me that with a rail designed with such care for great stability in the proportioning of the web and base, and long life, in the proportioning of the head, this feature might be worthy of some consideration, and

some metal be added underneath the tram where it is now hollowed out.

I also believe that the addition of some metal underneath the deepest part of the tram, at the fishing line, would be desirable, for the purpose of strength, possibly easier rolling (if the metal further along the tram is thickened), and principally to avoid the necessity of making the groove of the guard rail shallower than the straight track rail, as is now proposed, for the reason which I will explain later. The heavy dotted lines on Exhibit B represent the idea as to how the metal might be added.

The 7-in. girder grooved section seems to me well proportioned, in comparison with the 9-in section, but the same remarks in regard to the thickness of the tram of course apply.

The girder guard rails certainly should fish perfectly with their connecting grooved-girder rail, and the principle to make the girder guard sections in all essentials affecting this exactly identical with the grooved girder rails is, in my opinion, undoubtedly correct. The groove of the girder-guard rail, in my opinion, is correctly designed and of proper dimensions, as to width, to cover the practical requirements. The rise of the guard of $\frac{3}{8}$ in. above the head is not only accepted practice, but is necessary for some of the small flanged wheels which are still used in many cities. For a $\frac{5}{8}$ in. deep flange, for instance, a guard less than $\frac{3}{8}$ in. would hardly be safe on sharp curves.

The only thing that I might suggest again is that the guard is not thick enough. On the same lines as in my above remarks on the thickness of the tram of the straight track section, I submit herewith in Exhibit C an extreme composite wear line of both inside and outside rails, obtained from a number of worn sections, with $\frac{7}{8}$ in. flanges, and it will be seen that again, if a rail is allowed to wear as much as some have been allowed to wear, the guard, as designed, would become extremely thin and undoubtedly bend or break before that point was reached.

It should be further considered that in many cities we have to contend with the fact that interurban cars, with

M. C. B. flanges, are run over the city tracks, and around the curves in the city streets, i. e., that we have to provide for a combination traffic of ordinary flanges and M. C. B. flanges. It would hardly appear desirable on the part of the railway company in such cases, to go to the special sections of girder guard rails that are rolled for use with M. C. B. flanges, but the usual method to provide for occasional interurban cars mixed in with the city cars is to widen the groove of the regular guard rail by planing; planing has also to be resorted to with the Association Standard flanges when the curves get below 40-ft. radius or the wheel bases above 6 feet.

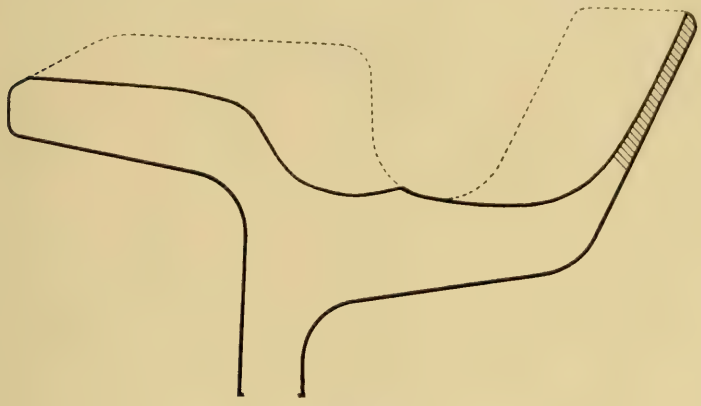


Exhibit C

In such cases, therefore, the initial thickness of the guard would be further reduced, which adds another point to the desirability of making the guard in the standard section thicker from the start. It is also the provision for the M. C. B. flanges that we run up against, in connection with the city flanges, that made me say that it is undesirable to make the groove in the girder guard rail only 1¼ in. deep, and the same depth as in the straight track rail, i. e., 1⅜ in. should be maintained and the metal added underneath, at the fishing section.

Summing up, I submit drawings Exhibits D and E of the sections showing how they would look with these modifications.

If there is objection to this added metal, on account of the added weight, it seems to me that the stem might be thinned

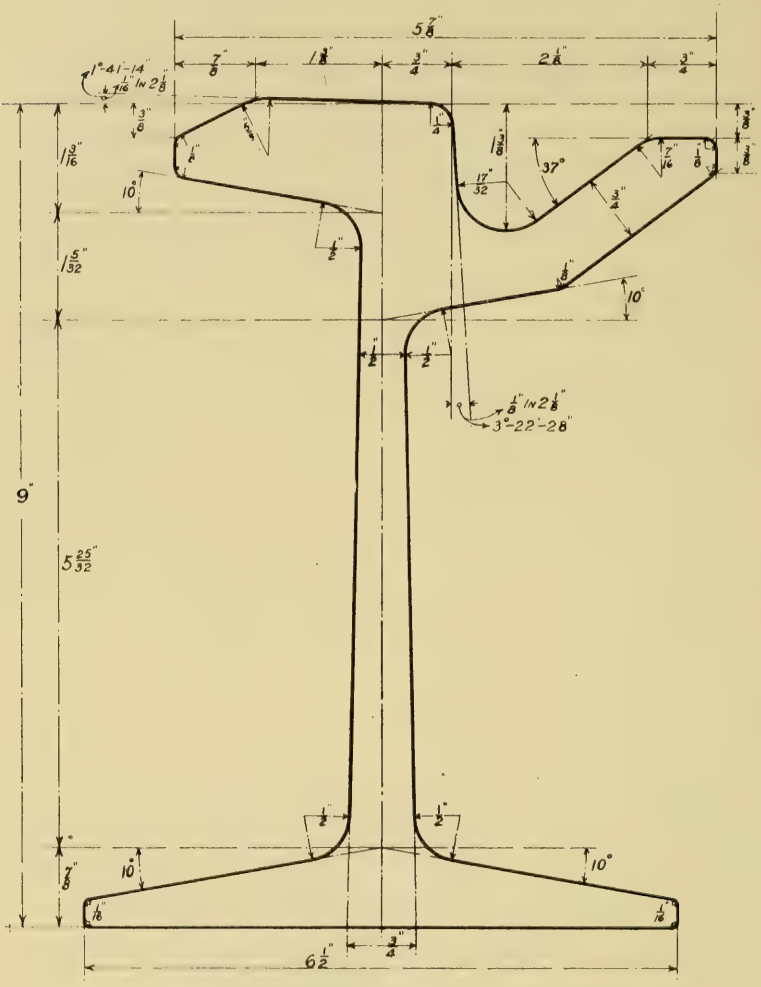


EXHIBIT D

slightly, or even the base narrowed slightly, to compensate for it, without detracting from the section.

Not having anything to do with the rolling of rails for quite a number of years, I am not qualified to say any-

thing on the question of any difficulty that these sections might present to the mill over the present sections in use, but from the standpoint of the special work manufacturer,

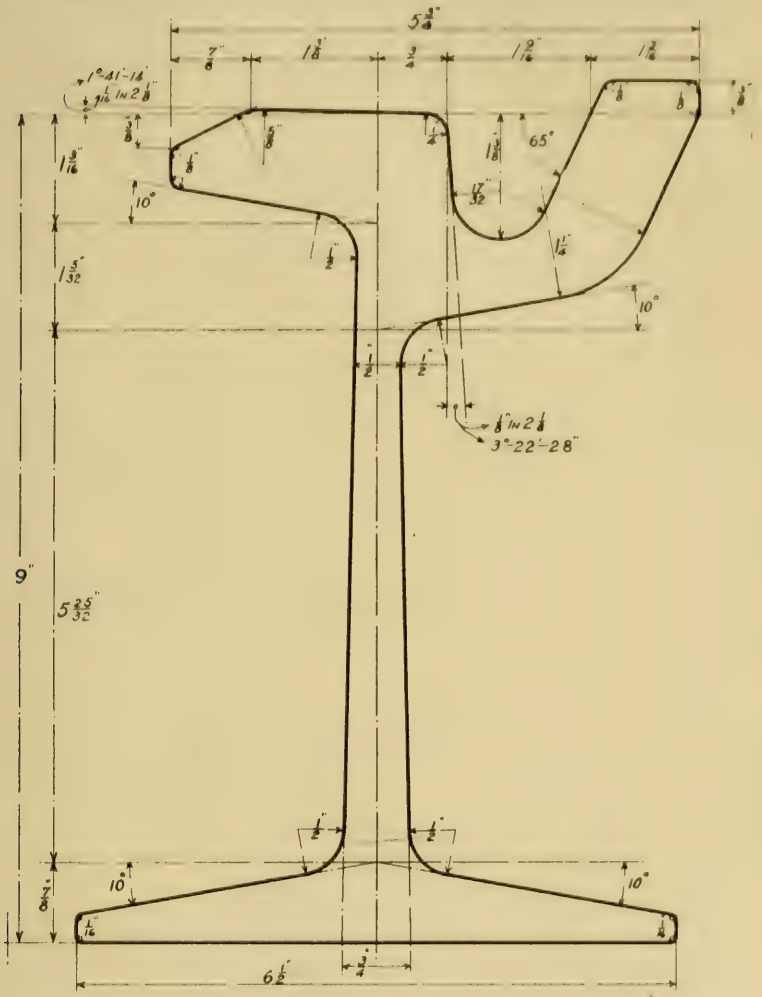
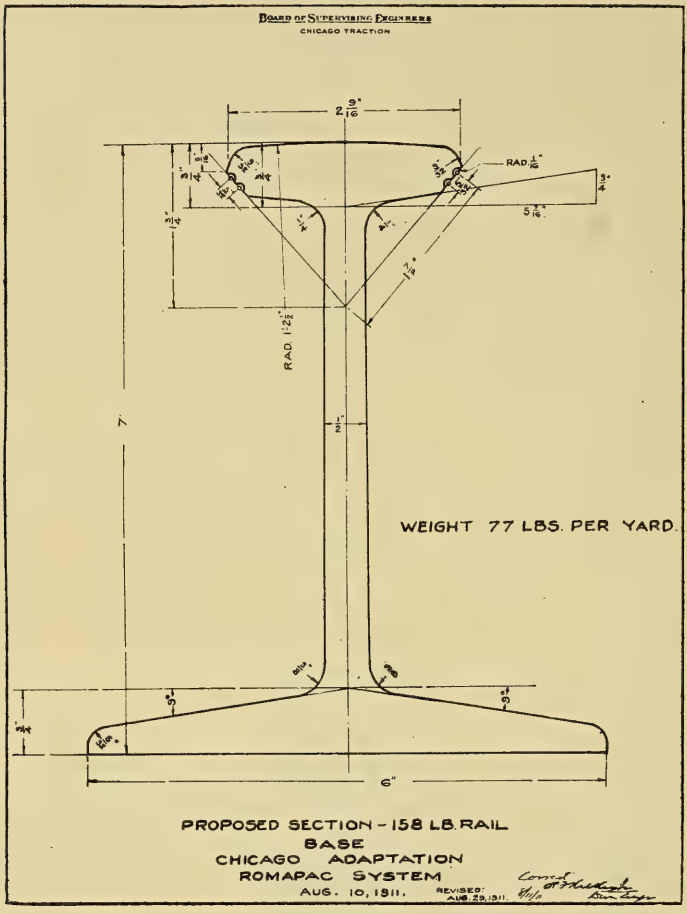


EXHIBIT E

I see no objection to these sections, except that they would be somewhat more difficult to curve, on account of the wider base, and the tapered web might give some little

trouble, but just now how much that would amount to cannot very well be foretold.

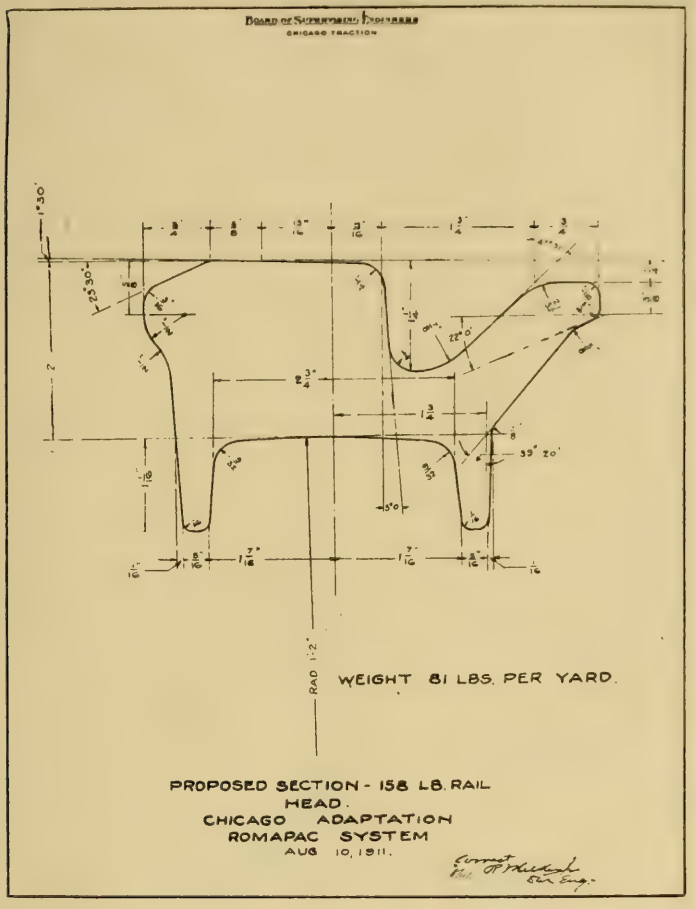
PRESIDENT ACKERMAN:— We have worked for some time to design rail sections which would fill the requirements of our members, and we would like as much discussion as pos-



sible for the benefit of the Committee next year. There is at all times, a rapid advancement in the art of electric railway engineering, and in order that we may have the record of some of this placed in our printed proceedings, I will call upon Mr. R. F. Kelker, Division Engineer of Track and

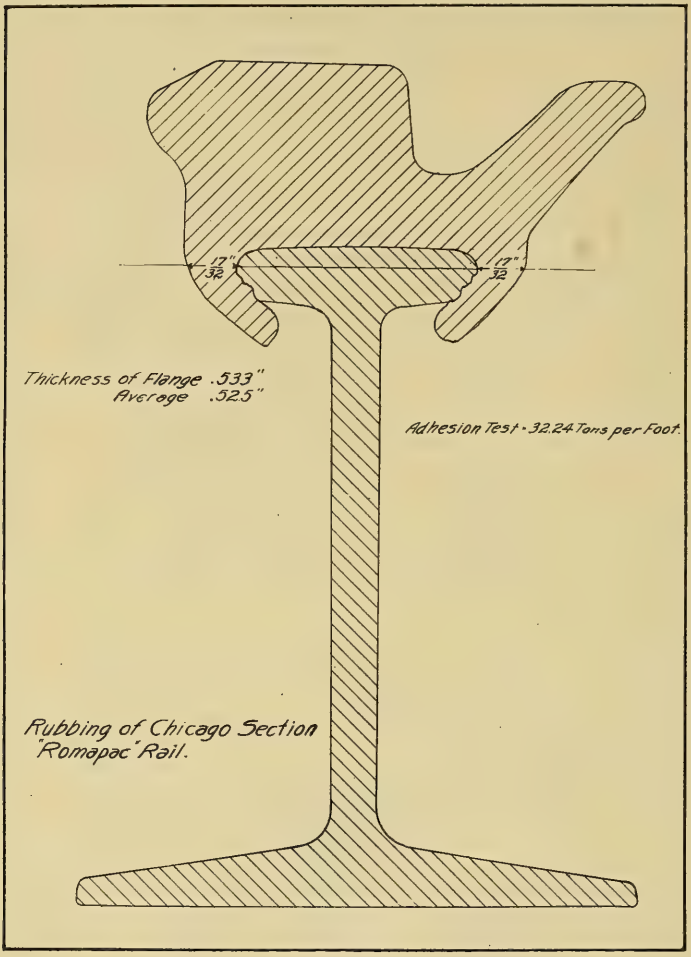
Roadway, Board of Supervising Engineers of Chicago, to address us on the subject of rail sections.

Mr. Kelker:— President Ackerman thought it might be well at this time to include in the discussion of rail, a short



description of the experiment with the Continuous Rail, which has been made here in Chicago during the past year, so as to benefit those who are here, and particularly those who have not been with us, and whose only opportunity to know of it is through the records of our proceedings.

Briefly, the Continuous Rail is a compound rail consisting of a base which is laid in the track in the ordinary manner, and a head section with depending flanges which is placed on the top of the base so that the joints in head section stagger



the joints in the base section. After the head section has been so placed, the machine is run over the track and crimps in the flanges of the head section so as to form what is in reality a compound girder.

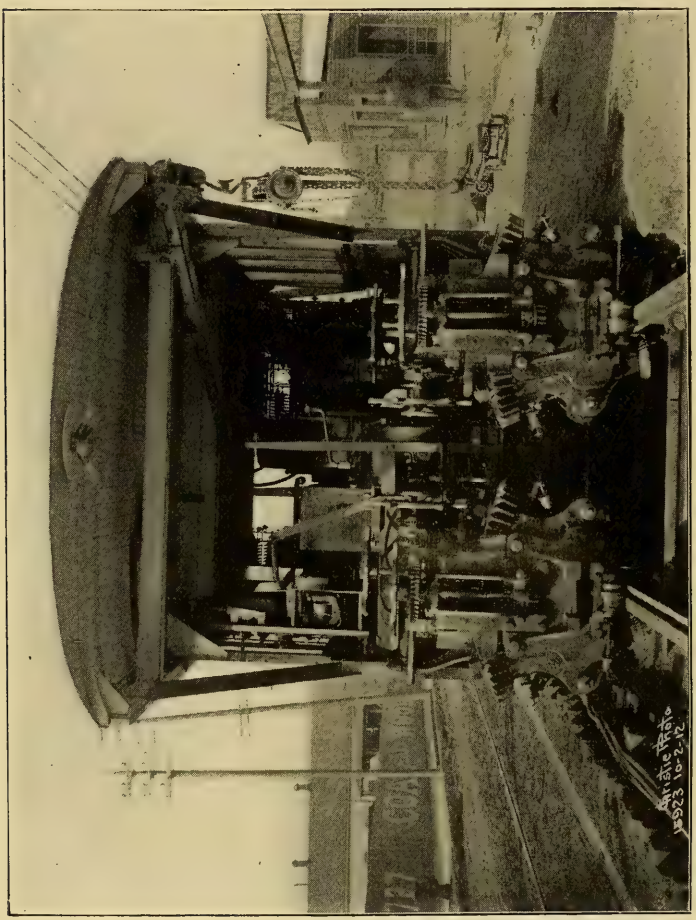
The process and the machine for crimping the rails together are the invention of Mr. Edgar Rhodes, an English mechanical engineer. Before introducing this system into America, it had been tried out in England and France. The action of the machine upon the flanges of the rail is novel and ingenious. As the machine passes over the rail, two opposing rollers engage the depending flanges of the head section; and from the beginning of the operation, cause the metal to flow in waves. As the operation continues the flanges are cold-rolled until compression strains develop on their outer sides, converting them into powerful springs which grip the head of the base rail, and forcing part of the flange into the longitudinal grooves which are cut on the under side of the top of the base. The resistence of this grip to a force exerted to slip the head along the base has been shown by tests made by Messrs. Hunt & Co. to be over 36 tons to the running foot.

The machine which was brought over last year to crimp the Chicago section was designed to work upon a rail having flanges 3/8 in. thick, of .45 carbon steel. It was called upon to handle flanges of .60 carbon steel which in some cases had a thickness of over 1/2 in. As a consequence, this machine was overloaded from the start, and was unable to crimp more than 100 feet an hour. After a mile of track had been crimped on the west side of South Halsted Street between 31st and 39th Streets, weather conditions interrupted the work; and nothing further was done in the matter until last month.

In the meantime, a more powerful machine had been designed and constructed. This new machine is electrically driven; whereas, the machine which crimped the rail last year was operated by steam.

The new machine has just finished crimping one-half mile of track on the north side of 47th Street, west of Paulina Street; and in the first few days of its operation has shown its ability to crimp 680 feet of track, or 1,360 feet of rail in about one hour. It is designed to crimp 1,200 feet of track in an hour; and it is expected that the capacity of the machine will be increased when the bearings run smoothly and the new machine has settled down into its stride.

The rail laid on the west side of South Halsted Street was subjected to excessive variations of temperature during construction. The therometer, in one day, dropping from 74 to 12 degrees Fahrenheit. It has stood the test of the most severe



Machine Used for Crimping Rail Head.

winter ever known in Chicago; and has, this summer, been exposed to a heat of over 100 deg. when the thereometer registered 95 in the shade. An inspection of its present condition can easily be made, as the track begins a few blocks north of the entrance to this building on South Halsted Street.

It is the track on the west side of the street; that on the east side being laid with our standard construction.

An interesting feature has developed in connection with the method of manufacturing these rails in the rolling mill. Both trilby and T-rails pass through the rolling mill on their sides, so that during their manufacture the pressure of the main rolls is exerted upon the web of the rail, and only indirect pressure upon the wearing head. In the continuous rail, the base is rolled in the same manner, but the head is rolled upside down, so that the direct pressure of the main rolls is exerted during the last seven consecutive passes upon the wearing surface of the rail. The result is that the metal in the head of the rail shows great homogeneity and closeness of texture. The density of the metal, as compared with other rails, is only about 4 per cent. greater; but the effect of this increased density upon the electrical conductivity of the metal is very great.

The calculation is based upon tests made by Mr. Ralph H. Rice, Assistant Engineer of the Board of Supervising Engineers and Mr. A. A. Thurlby, Superintendent of Wires and Cables, Chicago City Railway Co., which shows that the metal in the head section of the continuous rail has about 74 per cent. greater conductivity than an equal section of the metal in our standard rail.

After the head had been crimped to the base, and the track was completed without any welding of the joints, the resistance of 1,000 ft. of continuous rail was found to be 0.004485 ohms; whereas, 1,000 ft. of our standard rail with the joints electrically welded showed a resistance of 0.00704 ohms. Twenty-two per cent. of this increase was due to the increased area of the cross-section of the continuous rail; and the balance must be ascribed to the method employed in the manufacture of the rails in the rolling mill.

For street railway purposes, the whole rail is crimped in tight from end to end; for exposed work, as, for example, on interurban lines, and on steam railroad lines, it is proposed to crimp in solidly about 90 per cent of the rail; and to avoid crimping compression strains on the remaining 10 per

cent. of the rail at each end, so as to form a sleeve joint between the upper and lower sections. The joints of the upper rail in the case of a 30-foot rail for street railway purposes would be placed midway between the joints of the lower rail, and for open work construction these joints would be placed three feet away from the joints of the lower section.

It is only fair to say that the foundation of the track south of 35th Street is of unrolled ballast, as the early appearance of frost last year made it inadvisable to fill in concrete in bulk, which was the original intention. Furthermore the exigencies of our traffic required us to run our cars on both sections north and south of 35th Street within a couple of days after the rail had been crimped; and the grinding of the joints was not taken in hand until last June — about six months after the track was laid. The south-bound traffic on South Halsted Street is 730 cars per day, so that about 230,000 cars, or 920,000 axles, have already passed over the continuous rail.

It is also to be noticed that there are no streets running directly across South Halsted Street — even the cross streets have staggered joints — so that motormen have no cross traffic to interfere with their running; and the traffic is speedy as well as heavy.

President Ackerman:—This may be a little diversion from our usual procedure of discussing only the subjects contained in the report of the Committee, but upon second thought, it seems possible that the matter which has just been presented to us may have some influence upon the design of a rail section for this Association, for the reason that a rail perhaps similar to the one already proposed could be given a top and bottom section, so that the method just described could be followed should anyone wish to do so.

(Secretary Litchfield then read a written discussion by Mr. R. C. Cram of the Brooklyn Rapid Transit System.)

Written Discussion by Mr. R. C. Cram

I have examined with much interest the advance report of this year's Committee on Way Matters. While I am in accord with the general substance of the report, I beg to call

attention to the design of the 7-in. grooved-girder rail, with particular reference to the width of the base, which is set at 5½ in.

I believe that this width is too narrow, for several reasons: *First*, as it is desirable to avoid the use of tie plates, the base should be as wide as possible so as to provide as much bearing area as can be conveniently rolled. This was determined by last year's Committee in the case of the 9-in. grooved-girder section, as being 6½ in. Another reason for added width is that spiking on the tram side is made easier and the spikes may be driven more nearly vertical.

I believe that the width of base in the 7-in. section should be made the same as that of the 9-in. section, and while the increase in width adds perhaps about 8½ lbs. to the weight, it certainly adds to the value of the section more than the extra cost due to same, to say nothing of the betterment to be obtained in rolling by having just so much more metal in the base, thus, more nearly balancing the amount in the head which has more than an equitable proportion of metal.

Further, most of the new 7-in. foreign rail sections have a 7-in. base, eight recent foreign sections being 7 in. high with 7-in. base and two being 7 in. high with a 6½ in. base, and five recent American sections have a 6 in. base, all of which gives further support to my contention for a wider base. In connection with the design of foreign rail sections, there is an excellent article in the *Engineering News*, Volume No. 67, No. 21, May 23, 1912, in which it is stated that the widest possible base should be obtained.

If our foreign brethren are willing to go to the extra cost, which our own makers say is entailed by a 7-in. base, we can well afford to have the widest possible base obtainable in this country without added cost, which is limited by our manufacturers to 6½ in.

It is also pointed out that, in the Analysis of the Rail Section, given in last year's report, under "2. vertical stability (c)," the advantages of the "Widest base possible to roll," are emphasized and under "4. horizontal stability (d)," width of base is given as an important factor and under "5.

Distribution of loads on foundation (a)," width of base is given as of "greatest importance" and under "9. Weight" it is stated that the base was designed for "Best bearing and spiking accommodations."

If those arguments were sound for a 9-in. rail they would seem to be sound for a 7-in. rail and I maintain that any reduction in the width of base, from less than 6½ in., the largest economical maximum, is contrary to the principles laid down in the Committee's own analysis, and also against good practice as evidenced by practically all recent designs.

Since most engineers are agreed, that the 7-in. is coming to be the generally adopted height of rail for city street work, it will be well to consider very carefully before we take any backward step in the design of a section which is becoming more and more important, and I am of the opinion that the adoption of a base 5½ in. in width would be a most unfortunate step backward.

I am further advised that your Committee was not in entire agreement on the 5½ in. base, so I feel that I am certainly not alone in my contentions.

PRESIDENT ACKERMAN:— We would like to hear from any other gentleman who cares to discuss this feature of the report. Mr. Alden, will you explain the rolling difficulties that will be encountered on account of the width of flange, to which you referred? What is the rolling difficulty with this particular section?

MR. ALDEN:— The 6½-in. base presents serious difficulties, and there are possibilities that the tapering web will do so.

PRESIDENT ACKERMAN:— That does not apply to the 7-in. section?

MR. ALDEN:— No, only the 9-in. section; the 7-in. rail is all right.

MR. KELKER:— I think it is very desirable that these three important phases, the width of the throat and the thickness of the metal in the lip of both the guard and tram, and width of base, should be considered for the benefit of the Committee. If the Committee has not definitely settled on the matter, the best they can do is to send the subject back to the incoming Committee for further consideration.

In regard to the width of the throat Mr. Angerer said it was satisfactory for a long time. It is impossible, in my opinion, to design a throat which will take care of every possible condition, and I think that a generally useful throat in dimensions of width is what we need. We can take our books and figure out theoretical throats until we are tired, but we cannot get our track foreman to lay the work out as we theoretically design it and that is where we fail. Different companies have different ideas about the widening of the gauge and planing of the head and planing of the guards, and it seems to me we should try to get something which will be generally applicable and not try to fit special cases, in regard to the length of wheel base and things of that kind. We should not attempt to make a guard rail which is only good for a special case, for then when you have some other case to be handled, you have something you do not want. I think that the thickness of the lip of the rail should be settled, and if we thicken it, which is desirable, it should be done on all sections. The desirability of two sections coming together on straight line and curve, without the use of compromise joints, is pretty well known.

The width of the base of the rail is another question. Almost everybody believes in a 6-in. rail and our 6½-in. is a little wider than that, and there is no reason why we should not have it (the wider base) if we think it is right, and if it is good for one rail it should be good for both 7 and 9-in. rail without regard to the height, as we use the base to transmit the loads to the foundation and to protect the ties. If we use a narrow base on the 7-in. rail, which is operated under the same conditions, it does not seem consistent. I think these points should be settled here so that the Committee next year can consider the matter and give us a rail which will suit everybody, and we will not have to spend our time in threshing out the subject again.

Mr. Merker:— The committee that designed and offered this rail this year was under the impression that what was desired was a rail that could be adopted as Standard. Several years ago standard flanges were adopted in which there was no great difference, so that as far as flangeway is con-

cerned there can be no appreciable difference. Mr. Angerer in his remarks has assumed that a flangeway and a thickness of the guard would have to be provided which would permit of the use of an M. C. B. flange. If that is what is necessary and what is desired in a standard, the flangeway and the guard which are offered for adoption are absolutely wrong. I do not believe, however, that we should provide a Standard to accommodate the M. C. B. flange, because the M. C. B. flange is not our standard.

The flangeway would have to be suitable for all conditions, and in determining that of course the minimum space would have to be taken care of. If a wider space is required on account of extending the wheel base, or reduced radius of curvature, there would have to be planing done. Of course, if this planing is going to be very great, if there are going to be any very extreme conditions, it would be difficult to design a flangeway which would accommodate all conditions.

Mr. Alden in his remarks fears the addition of more rail sections to those which already appear on the list. I think Mr. Alden should not fear that the intent of the Committee is to increase the number of rail sections, but, rather, hope that many of the rail sections that are at present rolled could be abandoned entirely. That is the object of standardization.

I do not care to discuss the other remarks that were made on the straight line rail, because the rail that was presented last year is what was given to the Committee for use this year, unless there was some great reason for making a change, and if the requirements of the Association are going to be that an M. C. B. flange shall be provided for, I think it would be necessary for next year's committee to change all of the rail sections. It will have to change the straight line rail as well as the guard rail.

Mr. French:— I think we are to be congratulated that we are so near the goal in the matter of selecting standard girder rails. We should hold to the essentials of these designs, but possibly change them as suggested in the criti-

cisms of Mr. Alden and Mr. Angerer, to whom I think we are greatly indebted for their kind advice in this matter. We have been working a long time to perfect the design of girder rails and should not lose the good work that has resulted in the rails submitted.

It seems to me that what we have been striving for is a girder rail that will fit ordinary conditions, and that, in the case of the guard rail, may be planed to suit extreme conditions as to flange room. As many companies are using standard flanges and others are working towards them, our standard rails should suit the conditions imposed by our standard flanges.

The aim of the Committee has been to design both a girder-guard rail and a straight rail that will fish, so that we will get away from the combination joint-plate bugbear. At the same time the suggestions made by Mr. Angerer regarding the guard rail must be embodied in the rail to make it satisfactory. The guard rail as shown by the dimensions is ⅛-in. shallower than the groove rail, in the flangeway. As Mr. Alden has well pointed out, we must add more metal to the flange of the guard rail to allow for planing for sharp curves. With that one change, which will necessitate the changing of the height of the inside joint plate, I think we will have a rail that should be adopted.

As to Mr. Alden's statement that the taper web may be scientifically all right, but perhaps implying that it is not practical, I do not think we ought to take that as an argument; he has not shown us why it is not practically all right. This rail has been given two years' consideration by the Committee. I am sorry that Mr. Voynow is not here to defend his theory as to the tapered web, but it has been well considered, and given thorough investigation. I think we should retain that feature of the design.

So far as the width of base is concerned, I am sure that the steel companies will be glad to get our orders for the 6½-in. base, and I do not think the extra half-inch will present any more difficulty in the rolling than the head would. It balances up the proportion of the metal in the base more

equally with the head, and tends to give the uniform stresses in both sections during cooling.

MR. MERKER:— I did not understand Mr. Alden's remarks on the tapered web, but I believe that he considers the taper web as a theory only. If it is a theory only, I think it is a perfectly good one. Is it not a fact that there are now some rail sections in the catalogs which have a tapered web?

MR. ALDEN:— Not to my knowledge, though it may be so.

MR. MERKER:— It seems to me I have seen them in the rail catalogs.

In regard to the drawings that Mr. Angerer made, of which I have a copy in my hand, he shows some excessive wear in guard rails. I do not believe that we should really attempt to provide for the wear that he shows in this drawing. No doubt guard rails have worn in just exactly the way he shows it, because he says he has taken plaster casts of these guard rails, but when a guard rail has worn as much as shown by Exhibit C page 627 it has ceased to be a guard rail.

So far as wear on the face of the guard is concerned, I wish to say for the benefit of the Committee, who will treat this matter next year, that the 3/8 in. that the guard is raised above the ball of the rail should be considered not only as a guard for a flange, which might be shorter than our standard flange, but also as an added 3/8 in. for wearing surface, which will lengthen the useful life of a guard rail.

MR. ALDEN:— In order to amplify what I said before, and in order to correct one or two remarks that were apparently based on a misapprehension of what I did say, I wish to say that the statement of the Committee, regarding the guard rail proposed has a groove of the right shape for a 50-ft. radius and a 6-ft. wheel base, is substantially correct. There is not any difference worth talking about. When our Section 283 was designed shortly after the A. E. R. E. A. flange was adopted, we made an investigation of a large number of pieces of special work in order to ascertain what radius the groove should be designed for. We found that 45 ft. was about the average radius, with a great number of curves less than that,

and as we desired to do the minimum amount of planing, and it was expected that the A. E. R. E. A. flange would be used, we took that into consideration. A width of 1 11/16 in. is not anywhere large enough for an M. C. B. flange on a curve. However, some roads are in use to-day with a larger flange than that — that is especially true in the West, while the flanges in the East will run smaller.

MR. SCHREIBER:— If I am correct in my understanding these discussions we are having here on the width of groove of guard rail have been more or less considered on the basis of theory or from drawings. A year or more ago I had this proposition to solve for myself, that is, to introduce a new guard rail to take care of a wheel base from four to six feet long, and for curves varying from thirty-five feet radius and up. The car wheel flange was the American Electric Railway Engineering Association "Standard" ¾ in. We went through the ordinary calculations to get the proper width of groove, at least two special work companies co-operating with us, and soon found that we could not get a groove that was going to be ideal for all conditions, so our best judgment was to design a guard rail with a groove 1 9/16 in. wide, which was afterwards rolled. When this decision was made we did not have the benefit of the labors of this Committee and I was agreeably surprised to see that this report contained the same measurements. I am glad to state we have been operating this rail now for some time under the conditions recited above and so far have obtained satisfactory results. The rail used was Lorain Section No. 443, 132 lb.

PRESIDENT ACKERMAN:—We will now interrupt the proceedings to receive a message from President McCarter, which will be presented by General Harries, the presiding officer of the Convention.

VICE-PRESIDENT HARRIES (American Association):— Just a word. I hesitate to interrupt you, knowing you are busy. I want to present Mr. McCarter's regrets (in which I am sure we all share), that illness makes it impossible for him to be here. An affectionately tyrannical household and an

arbitrarily faithful doctor insisted that a relapse from typhoid fever would be infinitely worse than the original attack, and they would not allow him to do that which he would normally and perhaps unfortunately have done.

For the American Association there is nothing more to be said, except there is great gratitude for the things accomplished by you gentlemen who operate largely with instruments of precision. If your work will permit you, of course you understand that there is a warm welcome for you at the closing session of the American Association (the sessions all being open), and there you will have an opportunity, even if you are not interested particularly in the program, which, however, is a good, broad, strong one, in seeing how we operate by main strength and rule of thumb.

MR. LARNED:— I want to thank Mr. Alden and Mr. Angerer and other members of the Association who have given us valuable suggestions for next year. I do not believe it advisable to attempt in Convention to decide the width of groove in the guard or thickness of metal in the tram. These questions should be fought out and discussed in Committee, where such matters should be decided in the first instance and where it will be possible to devote more time to the consideration of the reasons and arguments offered in support of the various changes recommended.

Mr. Angerer suggests that the thickness of the tram be increased slightly by decreasing the distance between the head and the flange. I do not wish to argue pro and con with reference to this, but simply to call attention to the fact that the way that Mr. Angerer suggests that this be done is as shown by his Exhibit D, page 628. This would call for a reduction of the fishing surface under the head, which I think would be very objectionable. Any improvement to be made in these rail sections should not be undertaken at the expense of such an important feature as the fishing surfaces, and if done in this way might prove distinctly detrimental.

Next year's Committee will no doubt, should it think proper to increase the thickness of the tram, be able to do

so in such a way as not to decrease the fishing surface. And now about the joints, we should have a good and efficient channel plate joint, as such joints are used in large quantities by many of our smaller companies who are not in a position to contract for the various forms of continuous joints, nor can our larger companies always apply such joints in small numbers economically. One of the principal causes for the short life of channel plate joints is lack of fishing surface, where the plates come in contact with the rail, and rails should therefore be designed with due regard to this feature, and since these rails have not been definitely approved, I would suggest that next year's Committee consider reducing the radius of the fillet under the head and tram and at the base next to the web of the rail, so as to give larger fishing surface for channel plate joints. The proposed radius is about 0.5 in. Some rails, notably Sections 283 and 273, as rolled both by the Lorain Steel Company and the Pennsylvania Steel Company — the numbers which I give are those of the Pennsylvania Steel Company — make these fillets less, thereby giving a greater fishing surface. I thank you, gentlemen.

MR. SCHREIBER:— I think this is the first time in the history of the Association that data was available for a Committee to make definite recommendations for standard girder rails, and I think in view of the report of this Committee and the discussion we have had on the subject, that next year's Committee can make a definite recommendation for 7 and 9-in. girder rails and 7 and 9-in. guard rails. It is unfortunate we have been so long accomplishing it, but the time was really necessary on account of the development of the art and the many conditions which have to be taken into consideration.

I move that we give the Committee a vote of thanks and that the incoming Committee on Way Matters be requested to take definite action next year.

MR. MERKER:— I desire to offer an amendment to Mr. Schreiber's motion. As to the number of rail sections to be considered next year, I would like to add two more to the

list, inasmuch as there has been a great deal of criticism from the manufacturers who must be considered in this matter. If the Association is going to provide for M. C. B. flanges, it will be almost a necessity to have two 9-in. guard sections and two 7-in. guard sections. I do not think the Association should standardize a rail for the M. C. B. flange, but it will not be a difficult matter for the Committee in making its design to add these two sections, and next year if the Committee on Standards does not care to adopt the two sections which will provide for M. C. B. flanges, they can very easily be dropped out. I, therefore, offer an amendment to make it six sections, instead of four.

MR. SCHREIBER:— I will change my motion to agree with Mr. Merker's suggestion, and instead of saying four rail sections, I will say rail sections. Now, whether the M. C. B. flange should be considered, that is a question for the Committee to decide. Personally, I do not see how it is practicable, nor the proper thing to do.

(The motion was put to vote as amended and adopted.)

MR. LARNED:— The next subject treated in the report is that of Alloyed Steel Rails. The Committee has made no recommendations, because the art has hardly developed to the extent that would permit this. We have simply confined ourselves to a review describing the different methods in vogue of hardening and toughening steel rails, and what the process consists of.

MR. DATZ:— In view of the fact that this is a progress report, I move that the report of the Committee be accepted.

(Motion duly seconded, stated and carried.)

MR. LARNED:— The next subject is the revision of our Specifications for Open Hearth Girder and High T-Rails. The original specifications were prepared in 1909 and it was subsequently suggested that they be considered jointly with the American Society for Testing Materials, and we have been for two years working with Committee A-1 of that Society on these specifications and we are now able to present revised specifications, that have passed through all the different stages prescribed by the American Society for Testing Materials

for making them the standard of that society and they will probably be adopted also by the International Society for Testing Materials as its standard.

The revisions generally have been beneficial, but there are still a few changes, according to my own opinion and that of some other members of the Committee, that might well have not been made, but for the sake of uniformity the Committee has presented these specifications as revised, with the recommendation that they be adopted by this Association as Recommended Practice. The original specifications and the reasons for making the changes together with the revised specifications appear in Appendix B of the report. These specifications have been passed upon favorably by the Committee on Standards and the next action toward making them the recommended practice of this Association is that they be approved by the Convention here assembled.

Mr. Schreiber:—As Secretary Litchfield explained yesterday the specifications for this rail is one of the best things the Association has ever done. The specifications previously adopted have been in use and given very general satisfaction and the revised specifications have been passed by the American Society for Testing Materials, and also by the Committee on Standards.

I take pleasure in moving that the report of the Committee in relation to the Specifications for Open Hearth Girder and High T-Rails be adopted as **Recommended Practice.**

President Ackerman:— Before the motion is put the Secretary will read some remarks on the subject from Mr. George L. Wilson, of Minneapolis, who is not able to be present this afternoon.

Written Discussion by Mr. G. L. Wilson

Having read the Specifications for Open Hearth Girder and High T-Rails, the writer congratulates the Committee upon its work in simplifying the specifications by the omission of duplicate and superfluous provisions. Also, in the improved clearness of statement.

It appears that the revision will require as careful mill work by the manufacturers and in some cases, more so, which will

be of benefit to the purchaser. The provisions in regard to the tests and rejections appear clear and definite enough so that both the manufacturer and inspector will understand what is called for.

The change in chemical composition by including provisions for high carbon, should be adopted by all engineers to obtain a better wearing rail for use under the conditions which exist in paved streets. It is in line with the writer's practice for the past five years. During this period, high T-Rails, with a carbon composition ranging from .75 to .90 and with phosphorus not over .03, have been used with entirely satisfactory results. No breakages have been experienced in the paved track and the amount of corrugation developing on this high carbon rail has been practically nothing as compared with a considerable amount on rails of other composition. It is a question of whether the silicon may not well be increased with advantage to the wearing qualities of the rail. This is being tried the present year by the writer and while the time is too short as yet for results to be shown, it is expected to continue the experiment in the future.

The changes in regard to discard, to the branding and finishing are improvements. The increase of accuracy called for in the height of rails will be of use in keeping the rail surface of adjoining rails in the same plane. Trouble from pounding joints begins with the fact that the ends of rails at joints do not form an exact plane, while with all forms of joint fastenings, it is recognized that the rails must be ground after the rails are in position, yet the more closely the abutting rails correspond, the better.

(Mr. Schreiber's motion was put to vote and carried.)

Mr. Datz:— Has the subject of the use of T-rails in paved streets been taken up?

Mr. Larned:— The use of T-rails in streets has been thoroughly discussed in recent reports of previous Committees and the discussion is spread on the records of the Association. The work of the Committee this year consisted in collecting data to show where T-rail is used with information as to ordinances and laws in reference to the use of the same. This

data has been collected and forwarded to the general secretary for filing. The present Committee is in accord with previous Committees in their recommendations but has not thought it necessary to reconsider this subject or make any additional recommendations.

MR. FRENCH :— I move that the report of the Committee be accepted and the thanks of the Association be tendered the Committee for their able and painstaking treatment of the subjects committed to them.

(Motion duly seconded, stated and carried.)

On motion duly made and seconded the meeting adjourned until 9.30 o'clock Friday morning, October 11, 1912.

FRIDAY MORNING SESSION

October 11, 1912

The meeting was called to order at 10 A. M., in the Brown Room of the Saddle and Sirloin Club; President Ackerman in the Chair.

President Ackerman :— Gentlemen, the first report on the program this morning will be that of the Committee on Heavy Electric Traction. Mr. Hazelton is here and I will ask him to present the report.

Mr. Hazelton :— Mr. Hill, the chairman of the Committee was unable to attend the Convention so he asked me to make a few remarks in his place. The report of a year ago was in connection with the location of the third-rail and third-rail structures and rolling stock. The report this year follows the one of last year and has reference to the location of permanent way structures in connection with the third-rail. There are only a few roads in this country where the location of the third-rail is defined by freight car clearances. The New York Central and the Pennsylvania are among those in the East. The clearances given in this report are such as to allow all freight and passenger rolling stock to run over a road provided with a third-rail without interference.

The second question that has been treated by the Committee this year is the location of automatic train stops. This is a subject that is coming to the front as automatic train stops are coming more and more into use. The diagram indicates the space that is available for the automatic train stops. For next year it has been proposed that two matters be taken up. *First:* The location and clearance of overhead working conductors, *second:* The effect of electrolytic action on metallic structures. This may include the question of possible electrolytic action in reinforced concrete structures.

REPORT OF THE COMMITTEE ON HEAVY ELECTRIC TRACTION

To The American Electric Railway Engineering Association:

GENTLEMEN.— Your Committee on Heavy Electric Traction held meetings in New York City on April 19 and July 2, 1912. Members of the Committee also attended the meeting of the Subcommittee of the Committee on Equipment for the consideration of automatic train couplers and the bearing which that Committee's proposed action would have on heavy electric traction installations.

The subjects referred to this Committee by the Executive Committee were considered at the first meeting and it was decided to deal this year with the following subjects:

1. Standard Clearance Lines for Third-Rail Working Conductors as Bearing upon Permanent Way Structures.

2. The Further Consideration of Clearances for Automatic Train Stops.

CLEARANCE LINES FOR THIRD-RAIL WORKING CONDUCTORS

The Committee last year recommended for adoption as standards of the Association the location and height of third-rail and clearance lines for third-rail structures and rolling equipment, as given in paragraphs 1, 2 and 3 of the Committee's report.* Its recommendations were endorsed by the 1911 Convention and approved by the Committee on Standards. The report last year, however, did not deal with the relation between the third-rail and permanent way structures, and the Committee is now prepared to recommend a limiting clearance line for permanent way structures.

Since the Convention of the Association last year, the American Railway Association and the American Railway Engineering Association have adopted as standard the clearance lines affecting rolling equipment as recommended by your Committee last year, and also the clearance line for permanent way structures now recommended.

The limiting clearance lines for third-rail, permanent way structures and equipment, including both lines, adopted last year and additional line now recommended, are shown in Fig. 1.

Your Committee recommends that the following be adopted as Standard:

The clearance lines for third-rail and permanent way structures and rolling equipment to be as shown in Fig. 1, thus reserving the space within lines AT, BT, CT, DT, ET, FT and AT, JT, KT, LT, MT for third-rail structures; rolling equipment not to en-

*See page 167, 1911 Proceedings—American Electric Railway Engineering Association.

croach upon the third-rail space under conditions of maximum wear and deflection beyond the line AE, BE, CE, DE, EE, FE, GE, and permanent way structures not to encroach upon the third-rail space beyond the line AS, JS, KS, LS, MS; this leaves a clearance space or neutral zone of one inch both horizontally and vertically upon which neither the third-rail structures nor equipment shall encroach. On curves of less radius than 800 feet, the third-rail must be moved back and the equipment may be allowed to swing outward as indicated by the lines and notes on the diagram.

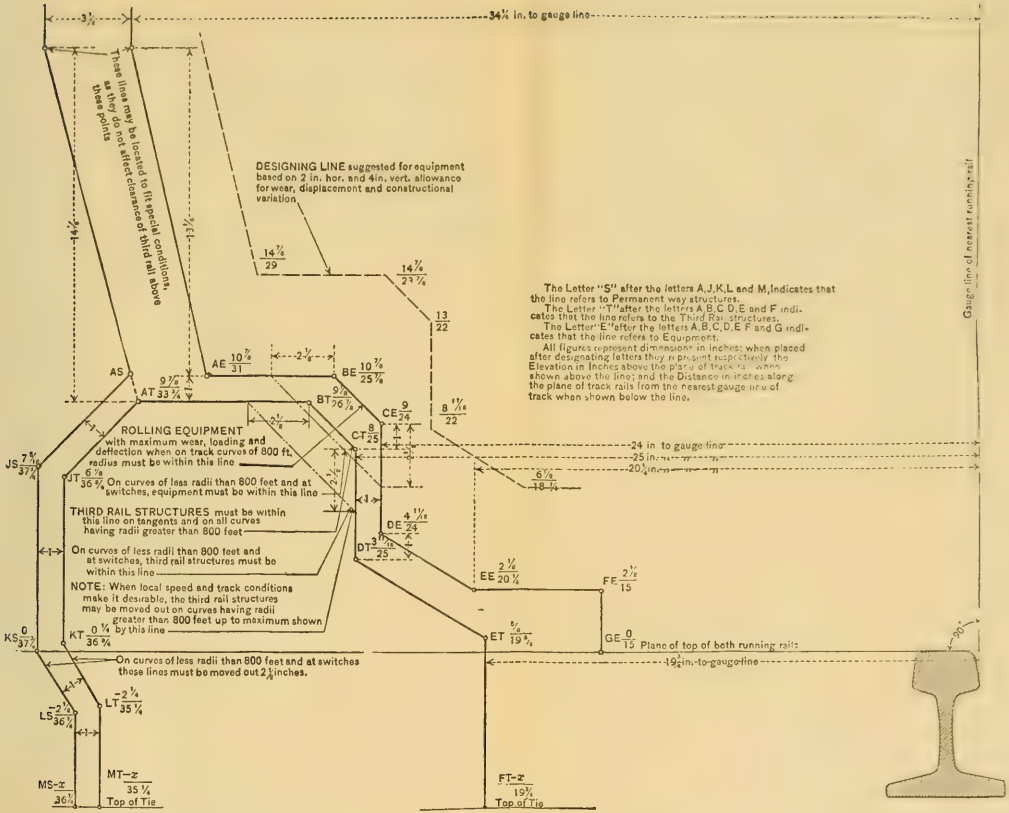
NOTE.—The Committee proposes no change in recommendations 1 and 3 of last year (see p. 167, 1911 Proceedings) as to the location of third-rail proper and the designing line for new rolling stock which has been repeated on the diagram (Fig. 1), it being understood that these have already been adopted as **Standard.**

CLEARANCES FOR AUTOMATIC TRAIN STOPS

Following the action of the Committee on Standards last year, the Executive Committee referred to your Committee on Heavy Electric Traction the subject of clearances for automatic train stops for further consideration or non-consideration, as this Committee should deem advisable, with the suggestion that if the subject be further considered it would be well to act in conjunction with the American Railway Association and the American Railway Engineering Association.

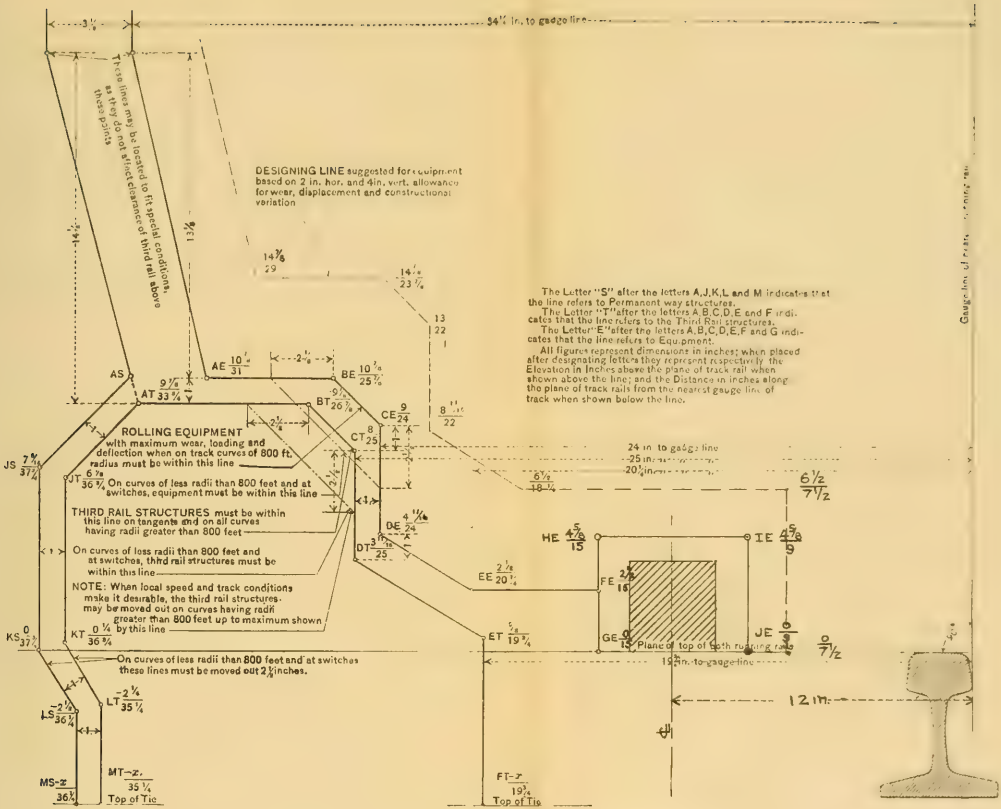
This Committee deemed it advisable to investigate the subject to the extent of conferring with the other Associations and ascertaining their views as to the desirability of establishing "recommended practices," and accordingly, at the Committee's request, the Secretary of your Association wrote the Secretaries of the other Associations and the subject is now before the proper Committees of the American Railway Association and American Railway Engineering Association. There has not been sufficient time since these matters were taken up to ascertain the views of the Committees of the other Associations as to whether clearance lines could be established, and it will be necessary for the Committee on Heavy Electric Traction next year to follow up the matter with the Committees of the other Associations mentioned.

For the information and guidance of those interested in the use of automatic train stops, the location as shown in the report of the Committee last year, together with the relation of clearance lines for the automatic train stop to the standard clearance lines for third-rail working conductors, are shown in Fig. 2, the portion of the diagram referring to the train stop being embraced within the line HE, IE, JE. It should be noted that the vertical and horizontal distances between the limiting clearance line for equipment and the designing line for equipment is less than for the third-rail, for the reason that the stop is located at a point where it is usually not affected by deflection of springs but only by the


34¼ in. to gauge line
These lines may be located to fit special conditions, as they do not affect clearance of third rail above these points
DESIGNING LINE suggested for equipment based on 2 in. hor. and 4in. vert. allowance for wear, displacement and constructional variation
The Letter "S" after the letters A,J,K,L and M,indicates that the line refers to Permanent way structures.
The Letter "T"after the letters A,B,C,D,E and F indicates that the line refers to the Third Rail structures.
The Letter "E"after the letters A,B,C,D,E F and G indicates that the line refers to Equipment.
All figures represent dimensions in inches: when placed after designating letters they represent respectively the Elevation in inches above the plane of track rail when shown above the line; and the Distance in inches along the plane of track rails from the nearest gauge line of track when shown below the line.
Gauge line of nearest running rail
ROLLING EQUIPMENT with maximum wear, loading and deflection when on track curves of 800 ft. radius must be within this line
On curves of less radii than 800 feet and at switches, equipment must be within this line
THIRD RAIL STRUCTURES must be within this line on tangents and on all curves having radii greater than 800 feet
On curves of less radii than 800 feet and at switches, third rail structures must be within this line
NOTE: When local speed and track conditions make it desirable, the third rail structures may be moved out on curves having radii greater than 800 feet up to maximum shown by this line
On curves of less radii than 800 feet and at switches these lines must be moved out 2½ inches.
24 in. to gauge line
25 in. to gauge line
20½ in. to gauge line
19½ in. to gauge line
Plane of top of both running rails
Top of Tie
Top of Tie
AS
AT 33¾
AE 10⅞ 31
BE 10⅞ 25⅞
BT 26⅛
CE 9/24
CT 8/25
DE 4 11/16 24
DT 3/25
EE 2⅛ 20¼
FE 2½ 15
ET 5/8 19¾
GE 0 15
JS 7⅛ 37¾
JT 6⅞ 36¾
KS 0 37¾
KT 0¼ 36¾
LS 2½ 36¼
LT 2¾ 35¼
MS-x 36¼
MT-x 35¼
FT-x 19½
14⅛
14¾ 29
14¾ 23⅞
13 22
8 11/16 22
6⅞ 18¼
2¼
2½
2⅛
4
30°

652a

FIG. 1. RECOMMENDED STANDARD FOR LIMITING CLEARANCE LINES FOR THIRD-RAIL AND PERMANENT WAY STRUCTURES AND ROLLING EQUIPMENT.


DESIGNING LINE suggested for equipment based on 2 in. hor. and 4in. vert. allowance for wear, displacement and constructional variation
These lines may be located to fit special conditions as they do not affect clearance of third rail above these points
The Letter "S" after the letters A,J,K,L and M indicates that the line refers to Permanent way structures.
The Letter "T" after the letters A,B,C,D,E and F indicates that the line refers to the Third Rail structures.
The Letter "E" after the letters A,B,C,D,E,F and G indicates that the line refers to Equipment.
All figures represent dimensions in inches; when placed after designating letters they represent respectively the Elevation in Inches above the plane of track rail when shown above the line; and the Distance in inches along the plane of track rails from the nearest gauge line of track when shown below the line.
ROLLING EQUIPMENT with maximum wear, loading and deflection when on track curves of 800 ft. radius must be within this line
On curves of less radii than 800 feet and at switches, equipment must be within this line
THIRD RAIL STRUCTURES must be within this line on tangents and on all curves having radii greater than 800 feet
On curves of less radii than 800 feet and at switches, third rail structures must be within this line
NOTE: When local speed and track conditions make it desirable, the third rail structures may be moved out on curves having radii greater than 800 feet up to maximum shown by this line
On curves of less radii than 800 feet and at switches these lines must be moved out 2½ inches.
Plane of top of both running rails
Top of Tie
Top of Tie
Gauge line of track
12 in.

652b

FIG. 2. SUGGESTED LOCATION AND CLEARANCE LINES FOR AUTOMATIC TRAIN STOPS.

wear of tires, journals, etc. The stop arm is usually flexible and it would be only elevated above the top of the rail when the signal is set against the train, and under these circumstances it is believed that clearances can be less than for continuous rigid structures.

Your Committee would recommend that the Committee on Heavy Electric Traction next year be asked to take up, in co-operation with Committees of the American Railway Association and American Railway Engineering Association, the following subjects:

(1) Location and clearances of overhead working conductors.

(2) The effect of electrolytic action on metallic structures, including the compilation of data on existing installations with a view to determining means of anticipating and preventing electrolytic action.

Respectfully submitted,

E. R. Hill, *Chairman*,
J. H. Davis,
E. F. Gould,
Hugh Hazelton,
E. B. Katté,
W. S. Murray,
Committee on Heavy Electric Traction.

President Ackerman:— Gentlemen, the report is now before you.

Discussion of Report of the Committee on Heavy Electric Traction

Mr. Storer:— I would like to inquire what the general objections to the use of this automatic train stop are? Why hasn't it been put into use before? I understand it has been in use to some extent for ten years on the elevated and subway lines of Boston.

Mr. Hazelton:— The principal objection to the use of the automatic train stop is its cost. I can not see any other valid objection, although there is, as I know, some difficulty in the use of automatic train stops out in the open, due to interference from ice and snow, but this trouble, has been fairly well overcome by several different plans. The automatic train stop has been used to the greatest extent in subway and elevated work, where the headway is very short.

SECRETARY LITCHFIELD:— I might say the scope of the Committee was simply on the location of the train stop, not on the desirability of it. That was not within the Committee's province.

PRESIDENT ACKERMAN:— Gentlemen, we have the recommendation of the Committee, given on the bottom of page 651 and the top of page 652. I would say that the Committee on Standards approved this recommendation, and I will now ask this body to take some action.

SECRETARY LITCHFIELD:— I do not know whether it is allowable for the Secretary to make a motion, but as a member, of a road that is equipped with third-rail I would like to make that motion, and I call your attention to the paragraph immediately above, which says that the subject is now before the proper committees of the American Railway Association and the American Railway Engineering Association. It is my understanding that our Committee this year has been in close touch with those organizations, so that the three organizations directly interested in this matter have practically all agreed, however, I believe that we should give credit to our Committee for instituting the matter. I, therefore, make a motion that the recommendation of the Committee with regard to clearance lines for third-rail and permanent way structures and rolling equipment as shown in Fig. 1 of the report be adopted as **Standard.**

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next recommendation of the Committee is that the following subjects, viz.: "location and clearances of overhead conductors," and "the effect of electrolytic action on metallic structures, including the compilation of data on existing installations, with a view to determining means of anticipating and preventing electrolytic action" be taken up by next year's Committee on heavy electric traction. What will you do with this recommendation?

MR. ALLEN:— I move that the report of the Committee be adopted and a vote of thanks be extended to them for their report.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next report before the meeting is that of the Committee on Equipment. I will ask Mr. Phillips to come forward and present the report of the Committee.

MR. PHILLIPS:— I shall not occupy too much time with unnecessary discussion of the report, for I presume you have all read and digested it, but will speak briefly on each of the topics considered by the Committee.

The Committee held its first meeting in New York, organized and laid out a program covering the work for the ensuing year, and appointed subcommittees to consider each of the subjects assigned by the Executive Committee.

The first subject, which I wish to call to your attention, is that of Specifications for Wrought Iron. The Executive Committee instructed that we take this matter up in conjunction with the American Society for Testing Materials, in order to draft common specifications, but after considering the subject for some time the Committee felt that from the standpoint of car equipment, aside from several minor parts of the car, such as grab irons, step irons, brake staffs, and tension rods in the brake apparatus, that it was not particularly interested in drafting wrought iron specifications. In addition to that, since the principal members of the subcommittee were unable to assist the Committee on Equipment this year, it threw this work into a rather chaotic condition.

The next subject is that of the matter of High Grade Rubber Insulating Compound. This was touched upon briefly in the report of the Committee on Power Distribution. The Executive Committee instructed these two Committees to consider this subject jointly with the understanding that they draft specifications for 30 per cent. Para rubber compound. The Committee on Equipment reviewed the specifications drafted by the 1911 Committee on Power Distribution, and as a Committee felt that the specifications reported by the Committee on Power Distribution were satisfactory to them. In the slight investigation made of this

matter, the Committee was unable to find a chemist who would say that he could determine even within 10 per cent. the amount of pure Para in a rubber compound. In other words, the means for determining the chemical composition of rubber insulation, particularly the Para content, are not such that they could be determined definitely. In consequence, therefore, we thought it hardly tenable to draft further specifications covering pure Para rubber. We feel, however, that the equipment men in general would be interested in specifications covering construction of cables and wires pertaining to equipment, and recommend that consideration be given to this matter the ensuing year. The subcommittee representing the Committee on Equipment and a like subcommittee from the Committee on Power Distribution had two meetings, one at New York and the other at Cedar Point, and this was the consensus of opinion of the representatives of the two committees.

The next matter I would call your attention to is that of End Wear on Journals. The situation was quite thoroughly canvassed throughout the country, and it appeared, as stated in the report, that the principal difficulty encountered with end wear on journals was found on the M. C. B. form; and, secondly, that the stop or button on the end of the axle, is, with the exception of the journal brass itself, subjected to the greatest amount of wear. The third conclusion was, "End wear is experienced chiefly where cars are operated at relatively high schedule speeds and where there are a comparatively large number of short radius curves." Considerable investigation was made to learn what means had been employed to overcome this wear and we report to you and describe the methods in general use.

The next subject is that of Self-Propelled Cars. I feel, speaking personally and not as a member of the Committee on Equipment, that we are greatly indebted to Mr. Holst and his subcommittee for the excellent paper they have prepared. The paper itself has been condensed somewhat and is not as elaborate as the original report, and in this con-

nection I would say that your subcommittee on Self-Propelled Cars has prepared a supplementary report, bringing the subject-matter up to September 28th. If it is in order to take up the supplementary report, I will ask the Secretary to read it at this time.

(Secretary Litchfield then read the supplementary report, for which see pp. 755 to 760.)

MR. PHILLIPS:— In keeping with the suggestion in the report, "The subcommittee also reports, that it has found the time allotted much too short to do thorough justice to the subject and to bring forth all the operating costs and service conditions, and therefore recommends that the subject be continued by a new committee."

In taking up the matter of Squealing of Steel Wheels, your Committee first sent out to the member companies data sheets asking for information, which ultimately were of little use, since very few replies were received thereto. The next movement was to begin service tests in various parts of the country.

I might say the tests were conducted simultaneously in two different parts of the country, where the service conditions were entirely dissimilar and that the results of the tests were almost identical.

That part of the report dealing with Heat-Treated Gears and Pinions does not involve any definite recommendations, but for the benefit of the members of the Association, results of the investigation covering particularly the physical properties of the various types of gears and pinions is shown in detail.

The subject of Couplers for Interurban Cars has been under investigation for several years with the idea of bringing about a common standard with this Association, the Central Electric Railway Association, and as far as possible with the American Railway Association, in order to cover conditions that exist to the greatest extent in the central western portion of the country. In order to expedite matters as much as possible, the Central Electric Railway

Association appointed Mr. L. M. Clark, a member of the Committee on Equipment of this Association, as its special representative on this and other matters to work in conjunction with this Association for the purpose of bringing about a common standard, and we present to you on page 678 Specifications for Couplers for Interurban Cars Where the Interchange of Equipment is Involved. There are certain operations in various parts of the country where an interchange of cars is quite unlikely in the near future, but the situation in the Central West, as stated before, is acute, and we trust that this matter will receive your approval. As was suggested the other day, we will concur in the recommendation that the specifications for couplers of the M. C. B. Association be printed in connection with the recommendations of your Committee.

In connection with the subject, Specifications for the End Connections on Interurban Cars Engaged in the Interchange of Cars, I wish to say that the standardization of the various end connections on cars is an intensely difficult thing to bring about. Your Committee did not attempt to make definite recommendations or specifications covering the construction of the end connections, but considered the location of the end connections themselves. This subject is of especial interest to the member companies in the Central West where there is particularly a large number of interchange cars in freight traffic, and to some extent in passenger traffic, and we recommend for your consideration the location of end connections on cars as illustrated by Fig. 6 of this report.

The next subject is the matter of the specifications for axles; *first,* Specifications for Cold Rolled Steel Axles and, *second,* Specifications for Annealed Carbon Steel Axles, Shafts and Similar Parts. The Committee prepared specifications for both of these types of axles and reported them to the Executive Committee. These specifications will be found on pp. 772 to 775 of this report, and are recommended to the Association for adoption as Standard. The Committee

on Standards at its meeting in New York, August 13th and 14th, considered these specifications and heard various representatives of the axle manufacturers. Considerable objection was raised to the sulphur limit in the chemical composition of the axles, and some question was also raised as to the exact meaning of the treatment of the warped axle in the Annealed Carbon Steel Axle Specifications. The Committee on Standards requested the Committee on Equipment to review this subject again, if possible before the Convention here in Chicago, and to take into consideration the requests and recommendations of the axle manufacturers concerning particularly the question of sulphur limit. Your Committee has considered the matter and have prepared a supplemental report which has been forwarded to the Executive Committee of the Association. (See pages 681 to 683.)

If you will refer to the Specifications for Cold Rolled Steel Axles on page 772, I will indicate the changes which are proposed. In the supplemental report, the Committee on Equipment substitutes, in the last line of Section 3: "Sulphur. . . . Not over 0.05 per cent." instead of "0.04 per cent." That is the only change in the specifications. In the specifications for Annealed Carbon Steel Axles, Shafts and Similar Parts, on page 775, in section 3, the sulphur limit is changed to the same value as in the Specifications for Cold Rolled Steel Axles.

A question was brought up by one of the manufacturers of axles as to Section 11 of the Specifications for Annealed Carbon Steel Axles, Shafts and Similar Parts, concerning the treatment of warped axles, and I was asked, personally, what was meant by it, and my answer was that if annealed axles were being treated for me, I should require them to be cooled in the furnace. Objection was then raised on the part of the manufacturers, some saying it was not necessary, etc., and they thought it should be left to the judgment of the inspector as to what should be the proper treatment of the axle after the straightening process, whether it should be cooled in the furnace or cooled on a rack or thrown indiscriminately on the floor of the mill.

The next subject with which the report deals is that of Specifications for Forged or Rolled Solid Carbon Steel Wheels for Electric Railway Service, which are printed in the report. The report on page 662 says: "In the preparation of Specifications for Steel Wheels, your Committee was greatly handicapped by the lack of standard tapes, gauges and templates by which the various tolerances could be determined. Further, since little or no data exists covering the physical properties of steel used in the manufacture of steel wheels, the specifications are lacking in these respects."

These specifications were taken up in conjunction with the American Society for Testing Materials, and the work is briefly described in this report. I shall not take your time to touch upon that, but would call your attention to the recommendation of the Committee in connection with this subject given on page 680: "It is further recommended to the Convention that a Committee be appointed to reconsider the design specifications, with special reference to the contours, and to devise suitable designs for standard gauges and tapes; also to investigate the means for providing suitable instruments and methods of making suitable tests that will determine the uniformity, hardness, etc."

To illustrate what your Committee intended by this recommendation, I will say that this Association has no standard tape for taping wheels, no standard ring gauges and various other gauges necessary to determine the tolerances of the wheel when completed. The M. C. B. standard tape will not fit the A. E. R. E. A. Standard contours. Your Committee recommends that this matter be considered further, keeping in mind these difficulties which were encountered this year in the drafting of these specifications.

REPORT OF THE COMMITTEE ON EQUIPMENT

To the Officers and Members of the American Electric Railway Engineering Association:

GENTLEMEN.— The Executive Committee of the Engineering Association referred to your Committee on Equipment the following matters for consideration and report:

Subject No. 1. High Grade Rubber Insulating Compound.
Subject No. 2. End Wear on Journals.
Subject No. 3. Self-Propelled Cars.
Subject No. 4. Squealing of Steel Wheels.
Subject No. 5. Heat-Treated Gears and Pinions.
Subject No. 6. Couplers for Interurban Cars and End Connections on Same.
Subject No. 7. Specifications for Steel Wheels.
Subject No. 8. Specifications for Wrought Iron.
Subject No. 9. Specifications for Cold Rolled Axles; Specifications for Ordinary Carbon Steel Axles.

Your Committee was also requested to review the Specifications for Heat-Treated Axles, Shafts and Similar Parts, reported upon by the Committee on Heavy Electric Traction, in 1911.

At a meeting in the Association headquarters on January 27, 1912, your Committee organized and mapped out a program for the season's work. Present at this meeting were Messrs. D. E. Blair, A. T. Clark, L. M. Clark, E. W. Holst, F. R. Phillips, and H. Gulick.

Mr. A. T. Clark, of Baltimore, was chosen Vice-Chairman of the Committee, and the following sub-committees were appointed:

Subject No. 1.— H. L. Patterson, *Chairman.* A. T. Clark and D. E. Blair.

Subject No. 2.— J. M. Bosenbury, *Chairman.* D. E. Blair and F. G. Grimshaw.

Subject No. 3.— E. W. Holst, *Chairman.* J. M. Bosenbury and W. Thorn.

Subject No. 4.— L. M. Clark, *Chairman,* and E. W. Holst.

Subject No. 5.— A. T. Clark, *Chairman.* F. G. Grimshaw and D. E. Blair.

Subject No. 6.— L. M. Clark, *Chairman.* H. L. Patterson and F. G. Grimshaw.

Subject No. 7.— E. W. Holst, *Chairman.* H. A. Benedict and H. Gulick.

Subject No. 8.— A. T. Clark, *Chairman,* and Carl F. Woods.

Subject No. 9.— F. R. Phillips, *Chairman.* J. S. Doyle and John Lindall.

On April 19 and 20, in Pittsburgh, Pa., this Committee again met for the purpose of reviewing the work in hand and to provide an opportunity for the manufacturers to present their views concerning the various subjects. Present at this meeting were Messrs. E. W. Holst, L. M. Clark, J. M. Bosenbury, H. L. Patterson, F. R. Phillips, and H. Gulick. The following manufacturing companies were represented: Carnegie Steel Company, Midvale Steel Company, Standard Steel Company, Standard Underground Cable Company, The Westinghouse Electric and Manufacturing Company, and the Westinghouse Traction Brake Company.

A final meeting of this Committee was held at Cedar Point, Ohio, on June 14 and 15, at which time all of the subjects under investigation were thoroughly discussed and the various sub-committee reports acted upon. Messrs. L. M. Clark, J. M. Bosenbury, H. L. Patterson, E. W. Holst, F. R. Phillips, and H. Gulick, were present.

It was early decided by the Committee that unless ample consideration could be given each phase of the particular subject under investigation, the matter would be referred back to the Executive Committee for further disposition.

In the matter of Specifications for Wrought Iron, and upon which the Executive Committee requested joint consideration with the American Society for Testing Materials, it is submitted that except for tension rods in brake apparatus, brake staffs, grab and step irons, where a good grade of common iron is essential, ordinary commercial open-hearth or Bessemer steel will meet the requirements, and that the quality of material called for in the proposed specifications for Stay Bolt and Engine Bolt Iron is not essential for car equipment purposes.

In the preparation of Specifications for Steel Wheels, your Committee was greatly handicapped by the lack of standard tapes, gauges and templates by which the various tolerances could be determined. Further, since little or no data exists covering the physical properties of steel used in the manufacture of steel wheels, the specifications are lacking in these respects.

We would, therefore, recommend that design specifications be prepared covering measuring tapes, gauges and templates for steel wheels and that the Committee be instructed to further consider the specifications with a view to inserting a paragraph covering the physical requirements of the steel.

It will be appreciated that the determination of the cause and remedy for Squealing of Steel Wheels was an exceedingly difficult matter, and while we are not prepared to state the exact cause thereof, we do believe the remedy has been found. Time would not permit a careful check of the result of tests made to establish

positively the remedy, and we would recommend that further tests be made to determine, first, the actual causes, if possible, and second, whether or not the remedy suggested in our report is commercially practicable.

The Central Electric Railway Association, through Mr. L. M. Clark, special representative of its Committee on Standards calls attention to slight variations between the specifications of the American Electric Railway Engineering Association and those of the Central Electric Railway Association, covering brake shoes and axles, and we would recommend that a special Committee on Equipment be appointed to confer with the Central Electric Railway Association with a view to bringing about a common standard for both Associations.

HIGH GRADE RUBBER INSULATING COMPOUND

The subject of 30 per cent. Para Rubber Compound, Section No. 1, Sub-Division C, of the report of the 1911 Committee on Power Distribution,* was referred back to this Committee by the 1911 Atlantic City Convention, with the understanding that the subject would be reconsidered jointly with the Committee on Equipment and that a further report would be prepared for the 1912 Convention.

Pursuant to this, sub-committees were appointed from both the Committee on Power Distribution and the Committee on Equipment, and a joint meeting of these sub-committees was called for February 24, 1912, at the Association headquarters in New York City. There were present at this meeting, representing the Committee on Power Distribution, Messrs. Gaylord Thompson, J. H. Barnard and John W. Corning, and as representing the Committee on Equipment, Mr. D. E. Blair. After a general discussion of the question, a method of procedure was decided upon and a date not later than April 15, 1912, fixed for a further consideration of the subject.

In the meantime, Mr. Corning, who had been appointed Chairman of the joint Committee, became ill, and the meeting had to be postponed, finally being called for June 13, 1912, at Cedar Point, Ohio. There were present at this meeting Mr. Gaylord Thompson, representing the Committee on Power Distribution, and Mr. H. L. Patterson, acting for the Committee on Equipment, who decided that, because of the illness of Mr. Corning and the inability of other members of the sub-committees to attend the meeting, no further action would be taken with reference to these specifications, and a report to this effect was submitted to the

* See page 87, 1911 Proceedings of American Electric Railway Engineering Association.

Committee on Equipment which met at the same place on June 14, 1912.

In considering this subject at the meeting of the Committee on Equipment on June 14, 1912, attention was called to the fact that the Committee on Equipment was interested in these specifications only insofar as this particular grade of insulation was involved in the equipment of rolling stock. Discussion of this subject with the representatives of various member companies raised some question as to whether or not with the additional cost of this high grade insulation its use in the equipment of rolling stock would be justified. Your Committee, therefore, feels that the subject of insulation for equipment purposes is deserving of much more investigation and consideration than can be given it under the present instructions, and recommends that the subject of specifications for wires and cables for equipment purposes, including the quality of insulation, the construction of wires and cables for different voltages and carrying capacities, and insofar as possible, the standardization of methods of wiring, including conduit wiring, be assigned to the Committee on Equipment for the coming year.

END WEAR ON JOURNALS

The matter of End Wear on Truck Journals has occupied considerable attention on the part of mechanical men for some time, and your Committee was instructed to investigate the situation with a view to suggesting a simple remedy to overcome the difficulty. Representatives of member companies from various parts of the country were interviewed regarding the matter and the following facts determined:

First, end wear on journals is confined almost exclusively to the M.C.B. form.

Second, the stop on the end of the axle is, with the exception of the journal brass itself, subjected to the greatest amount of wear.

Third, end wear is experienced chiefly where cars are operated at relatively high schedule speeds and where there are a comparatively large number of short radius curves.

That considerable thought has been given the matter is indicated by the various methods for overcoming the difficulty, the most prominent of which are as follows:

First, a hooded wedge, as illustrated in Figs. 1 and 3, with a renewable wearing plate and means provided for taking up the wear on the plate by installing shims between the plate and the inside of the hooded end of the wedge, is in fairly general use. This method offers the advantage of the use of a standard journal box, journal and wedge, the only difference being a slight modification of the wedge in the form of an extension.

The *second* most general method of overcoming the end play is the casting of guides integral with the journal box so that an end stop of malleable iron, faced upon its bearing surface with babbitt metal, can be dropped into the guides in close contact with the end of the axle, thereby imposing the lateral thrust of the axle upon the end stop rather than on the journal brass, the end stops being renewed by rebabbitting. This method is illustrated in

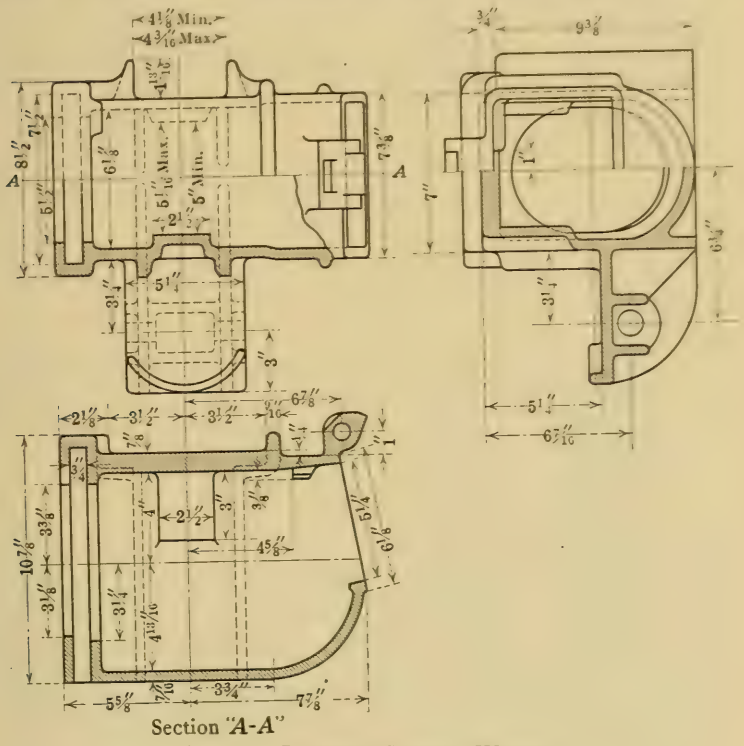


FIG. 1. SHOWING HOODED WEDGE.

Figs. 2 and 4. The chief advantages due to this method of overcoming end play are that the stress set up by the lateral thrust of the axle is placed more nearly in line with the axle itself and that the end stop may be easily renewed without jacking up the journal box. It also serves to hold the packing in place upon the lower portions of the journal and permits better inspection of the journal box. On the other hand, its use is only permitted in new journal boxes in which the guides are provided for. These guides, however, can be arranged in the journal box with little trouble and without interfering with any other parts and the use of the end stop would then be optional.

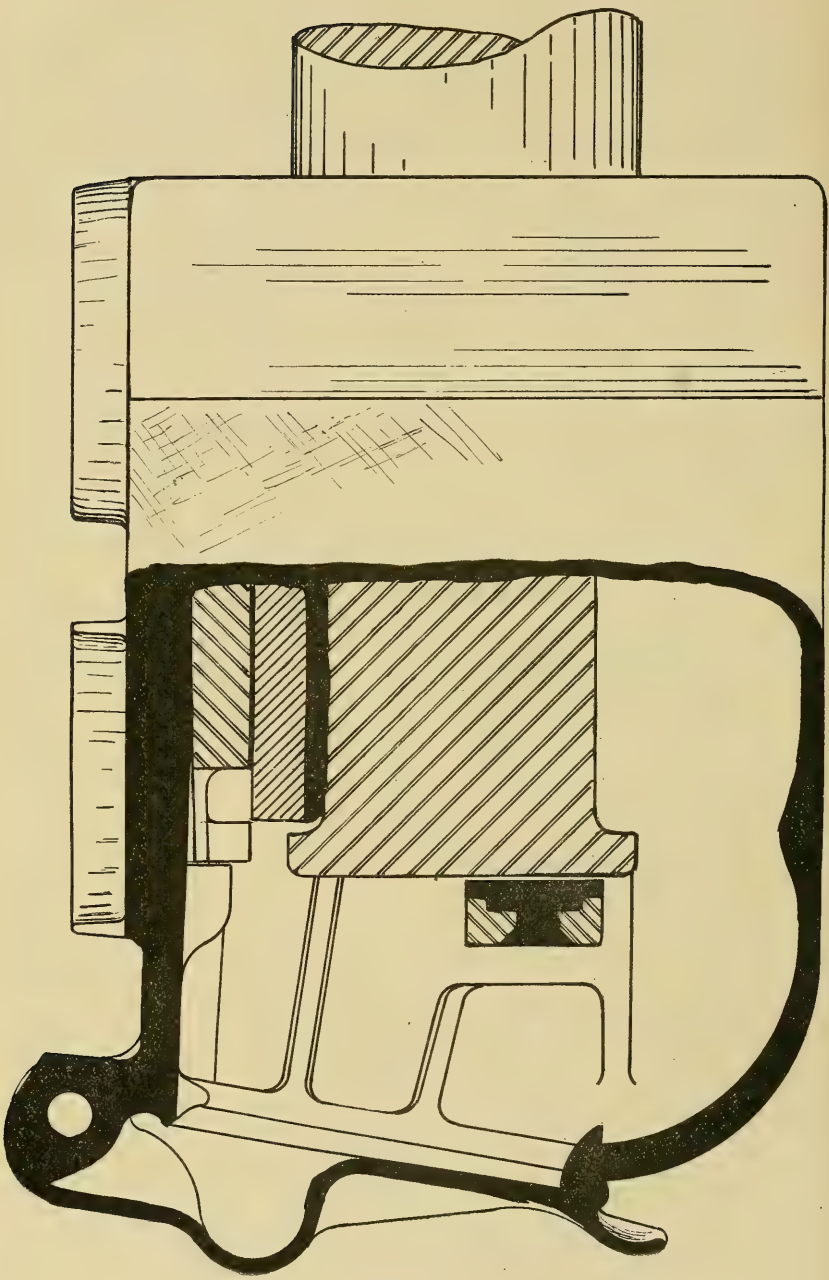


FIG. 2. CROSS SECTION OF INTEGRAL GUIDES CAST IN JOURNAL BOX.

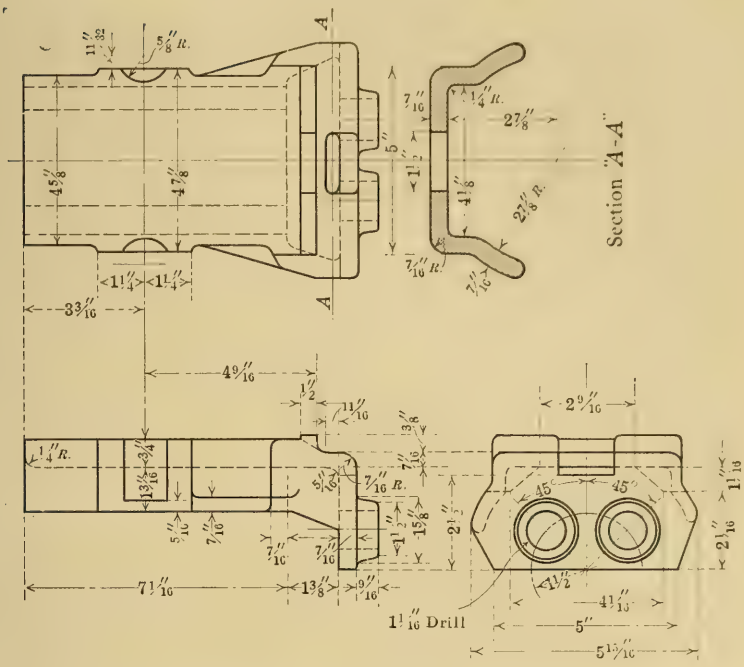


FIG. 3. SHOWING "HOODED" WEDGE.

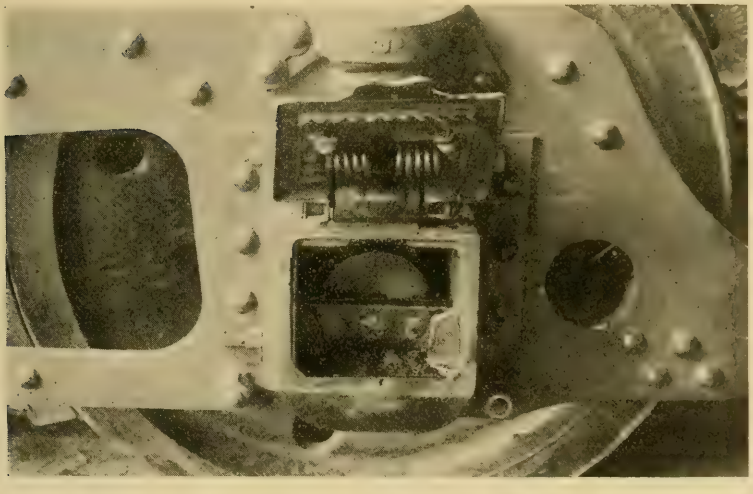


FIG. 4. SHOWING INSTALLATION WITH INTEGRAL GUIDES CAST IN JOURNAL BOX.

SELF-PROPELLED CARS

The Subcommittee having this subject in hand held meetings during the year as follows:

March 4, St. Louis, Mo. Present: Messrs. E. W. Holst and J. M. Bosenbury.

March 29 and 30, Pittsburgh, Pa., with the general Committee on Equipment.

May 31, St. Louis, Mo. Present: Messrs. E. W. Holst and J. M. Bosenbury.

June 14 and 15, Cedar Point, Ohio, with the general Committee on Equipment.

In view of the fact that this is the first time the subject of Self-Propelled Cars has been given attention by this Association, it was decided to prepare an historical development as one of the features of the report, and there is, therefore, presented a bibliography of matters of interest pertaining to the subject, in addition to an extended discussion of modern equipments and results.

The Subcommittee also reports that it has found the time allotted much too short to do thorough justice to the subject and to bring forth all operating costs and service conditions, and, therefore, recommends that the subject be continued by a new committee. The complete report of the Subcommittee is shown in Appendix A of this report.

SQUEALING OF STEEL WHEELS

The initial step taken in the study of the subject of the Squealing of Steel Wheels was the preparation of a Data Sheet based upon information previously in hand. This was placed in the hands of member companies and the majority of the replies received came from members who had had little or no experience with steel wheels. The balance of the answers contained a variety of widely ranging comments.

Extensive service tests embodying a variety of brake shoe, wheel, truck, track, and weather conditions were also conducted in an effort to first establish a condition under which the squealing of brake shoes was invariably present, and then to analyze this condition and, if possible, ascertain the cause and remedy. In addition, a great deal of valuable information was obtained from other sources, some of which checked with certain results of the tests.

The squealing of brake shoes, which exists to the greatest extent where steel wheels are used, and particularly in city service, may be defined as a vibration of short, high frequency waves, existing in the periphery of the wheel and developed by the process of friction between the brake shoe and wheel during running braking periods. This condition of squealing appears to be analogous to the sound developed by an unlubricated bearing on a line shaft in a factory, it being dependent upon absolute friction, as it practically disappears under the action of either lubrication or abrasion.

By the process of elimination, it has been definitely established that the difficulty, as it may be termed, is not primarily influenced by truck or track conditions. Squealing is produced on all types and compositions of wheels, being greatest with steel wheels having worn-smooth treads, considerably less with cast-iron wheels (attributable to their lower resonant factor), and initially absent with freshly-turned steel wheels where the absolute friction is low and the abrasion high. Variations in brake shoe compositions affect the squealing, being first dependent upon whether or not the shoes are provided with lubricating inserts, and in the instance of all-metal shoes, upon the division of the friction and abrasion resultant, the former being greatest with worn-in hard shoes, the latter with new soft shoes. Lubrication in the form of water on the track or suitable inserts in the shoes lessens or obviates the squealing, analogous to the application of lubricant to the dry line shaft bearing, and the recent work of the Committee has been directed to the ascertainment of the most desirable form, location and composition of inserts for the brake shoes.

Still pursuing the process of elimination through which it was determined that the squealing of brake shoes was not attributable to truck or track conditions, the experiments with the brake shoes were along the line of incorporating therein the feature of self-lubrication by providing inserts of different materials, such as lead, graphite, and asphaltum compositions, of various sizes and forms, locating them in various parts of the shoes. Up to the time of the conclusion of the tests it had been found that insertions of lead had proved the most efficient for the purpose intended and, contrary to expectations, the results which were derived by the employment of lubrication in this form were gratifying in that the coefficient of friction of the brake shoes was not lessened, in fact it was apparently higher, although the actual difference was not determined. The most satisfactory form and location of the lead inserts employed during the tests are shown in Fig. 5.

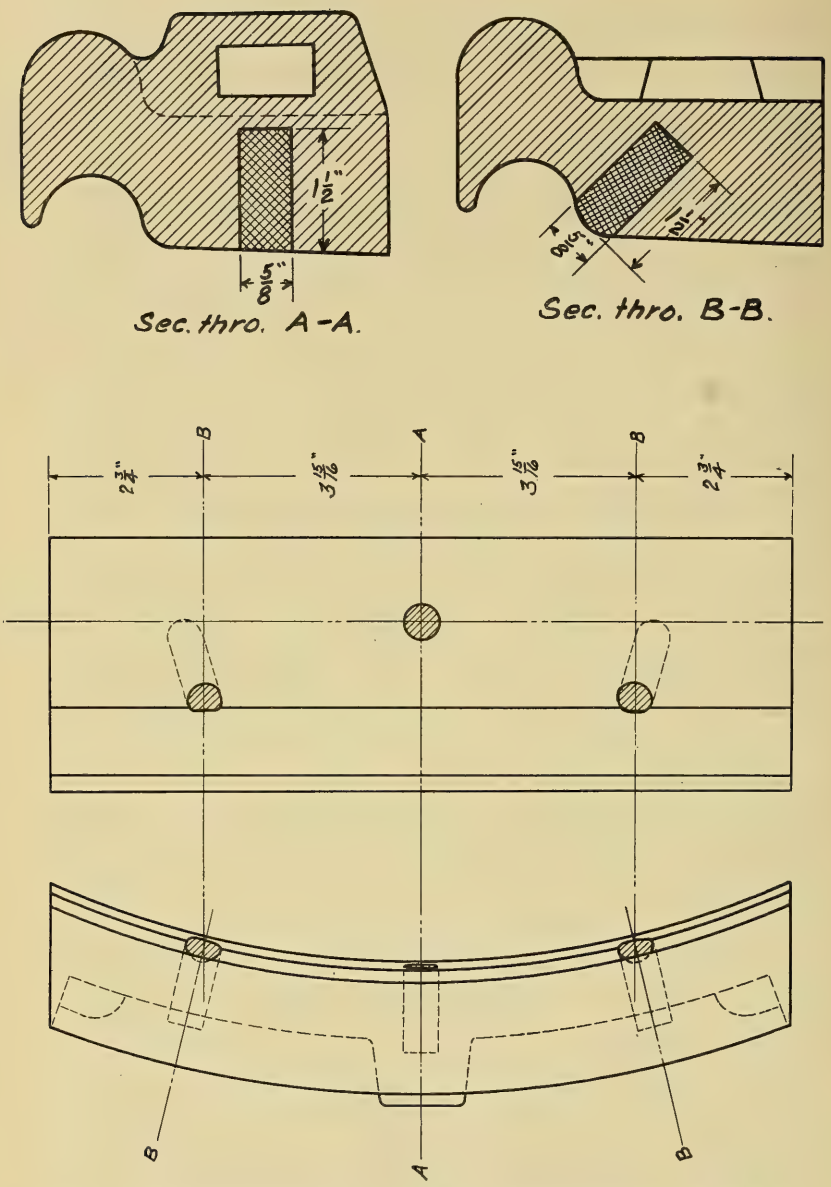


FIG. 5. SHOWING PROPOSED LOCATION OF LEAD INSECTS IN A. E. R. E. A. STANDARD FLANGED BRAKE SHOE.

While it is regretted that it has been impossible to formulate definite recommendations, your Committee feels that the question has been brought to a point which leads to the solution of the problem, and deems it advisable to recommend that the subject be referred back for further investigation and that there be included in the study the matter of the most practical form and arrangement of the self-lubricating feature for brake shoes and the actual effect which this function has upon the coefficient of friction under various operating conditions.

HEAT-TREATED GEARS AND PINIONS

The development of Gears and Pinions to meet the requirements of more severe and longer service has resulted in bringing the various methods of heat treatments and surface treatments and the use of special metals to the front.

A few years ago the cast steel gear was considered the best for railway service.

Today almost every gear and particularly the pinion is given some character of treatment to render the metal of higher unit working stress. In some instances they are treated by being quenched in oil from a high to a somewhat lower temperature. In other cases water is used for this quenching.

The result of these processes is such that the tensile strength and the elastic limit is greatly increased in the case of cast steel gears and more than doubled in the case of forged steel gears or pinions.

Since there is a great demand for gears and pinions in which the rate of wear will be reduced to a minimum, there have been brought forward three classes of products.

The *first* consists of those whose original soft texture has been hardened on the surface by one of the many methods of surface treatment. This results in giving a wearing surface so hard that it indefinitely prolongs the time that both gear and pinion maintain their full tooth section.

The *second* class of material used in the production of hardened gears and pinions is a method of converting the low carbon stock into high carbon tool steel stock.

The *third* method of hardening gear and pinion consists in the use of elements that when combined with the steel renders the product of an extremely hard nature such as manganese.

The use of hardened gears and pinions or their absence is a

matter of careful investigation. In some cases it is found that the best results cannot be obtained with the hardened products, since under the severe strain their teeth break out. In some cases high carbon oil treated stock is best.

However, for the average condition the hardened gear and pinion will produce results in lengthening the life of both the gear and pinion to at least twice that obtained with the gear and pinion not case hardened.

Recently there has been developed a rolled steel gear. This gear after being machined can be case hardened and represents the highest development in gear products.

A chart of the different characters of gears and pinions is as follows:

GEARS	Cast Steel	Plain	
		Alloy	Quenched
		Heat Treated.	Surface Treated.
	Forged or Rolled Steel	Plain	
		Alloy	Quenched
		Heat Treated.	Surface Treated.
PINIONS	Forged	Plain	
		Alloy	Quenched
		Heat Treated.	Surface Treated.

Many remarkable claims are made for the special gear and pinion products but before any definite decision is made concerning the results, the conditions under which the results were obtained should be carefully investigated.

Although no real line of demarcation can be made between the various kinds of gears and pinions yet it may be interesting to note some of the physical characteristics of each different kind when tested.

GEARS.

CAST STEEL:

Tensile Strength	About 60,000 lb.
Elastic Limit	About 25,000 lb.
Reduction in Area	About 20 per cent.
Elongation	About 18 per cent.
Hardness	About 140

GEARS — (*Continued.*)

CAST STEEL (Tempered in Oil):

Tensile Strength	About	75,000 lb.
Elastic Limit	About	45,000 lb.
Reduction in Area	About	40 per cent.
Elongation	About	24 per cent.
Hardness	About	200

FORGED STEEL:

Tensile Strength	About	85,000 lb.
Elastic Limit	About	55,000 lb.
Reduction in Area	About	35 per cent.
Elongation	About	22 per cent.
Hardness	About	165

CASE HARDENED (Forging and Casting):

It is impossible from self-evident reasons to obtain test specimens for case hardened products.

HARD ALLOY STEEL GEARS:

Tensile Strength	About	95,000 lb.
Elastic Limit	About	55,000 lb.
Reduction in Area	About	30 per cent.
Elongation	About	30 per cent.
Hardness	About	

PINIONS

FORGED PINIONS (Low Carbon):

Tensile Strength	About	55,000 lb.
Elastic Limit	About	25,000 lb.
Reduction in Area	About	35 per cent.
Elongation	About	50 per cent.
Hardness	About	150

PLAIN FORGED PINIONS (High Carbon):

Tensile Strength	About	85,000 lb.
Elastic Limit	About	50,000 lb.
Reduction in Area	About	40 per cent.
Elongation	About	20 per cent.
Hardness	About	200

HEAT-TREATED FORGED PINIONS (Low Carbon):

Tensile Strength	About	100,000 lb.
Elastic Limit	About	55,000 lb.
Reduction in Area	About	40 per cent.
Elongation	About	18 per cent.
Hardness	About	230

PINIONS—(*Continued*).

HEAT-TREATED FORGED PINIONS (High Carbon):

Tensile Strength	About	115,000 lb.
Elastic Limit	About	82,000 lb.
Reduction in Area	About	33 per cent.
Elongation	About	15 per cent.
Hardness	About	300

CASE HARDENED:

It is impossible from self-evident reason to obtain a test specimen for case hardened products.

SPECIAL ALLOY PINIONS:

Tensile Strength	About	95,000 lb.
Elastic Limit	About	55,000 lb.
Reduction in Area	About	30 per cent.
Elongation	About	30 per cent.
Hardness	About	

Hardness here quoted is obtained from tests with Brinnel Hardness Gauge.

The chemical composition of these various grades is shown in general as follows:

CAST STEEL GEARS:

Carbon	About	40 per cent.
Manganese	About	60 per cent.
Phosphorus	About	.04 per cent. (max.)
Sulphur	About	.04 per cent. (max.)

FORGED STEEL GEARS:

Carbon	About	40 per cent.
Manganese	About	60 per cent.
Phosphorus	About	.04 per cent. (max.)
Sulphur	About	.04 per cent. (max.)

FORGED STEEL PINION (Low Carbon):

Carbon	About	40 per cent.
Manganese	About	60 per cent.
Phosphorus	About	.04 per cent. (max.)
Sulphur	About	.04 per cent. (max.)

FORGED STEEL PINIONS (High Carbon):

Carbon	About	60 per cent.
Manganese	About	75 per cent.
Phosphorus	About	.04 per cent. (max.)
Sulphur	About	.04 per cent. (max.)

SPECIAL ALLOY PINIONS (Manganese):

Carbon	About 30 per cent.
Manganese	About 13 per cent.
Phosphorus	About .04 per cent.
Sulphur	About .04 per cent.

For the varying conditions of service the gears are named in the inverse order of their ability to meet the more severe demands required as follows: Cast Steel; Cast Steel, Oil Treated; Forged Steel; Case Hardened Cast Steel; Case Hardened Forged Steel; and Special Alloy.

The pinions rank as follows: Low Carbon Forging; Low Carbon Forging, Oil Treated; High Carbon; High Carbon, Oil Treated; Case Hardened; Special Alloy or Treated Pinions.

To properly and intelligently decide the quality of service to be expected from any gear or pinion and particularly the recent hardened products, a machine has been recently developed that will imitate the gear and pinion service under conditions and will hasten the rate of wear so that in a comparatively short time the relative rate of wear of any two different products can be ascertained.

COUPLERS FOR INTERURBAN CARS

The subject of Couplers for Interurban Cars was assigned by the 1910–1911 Executive Committee to last year's Committee on Equipment, which investigated the question at length and formulated requirements for interurban couplers, based principally upon the operating conditions in the Central West, where the issue is perhaps of greatest importance.

The Subcommittee assigned to the subject, taking into consideration the report of last year's Committee, prepared a Data Sheet which was placed in the hands of Member Companies, the majority of whom and especially those who were judged particularly interested, failed to return them with the desired information. This question, which is somewhat complicated, has been given much thought, attention being directed particularly to the Central West, where the requirements are typical. A conference with the Committee on Heavy Electric Traction was held in New York on June 3, 1912, the subject being discussed at length.

The principal factor of the requirements appears to be the feature of inter-coupling with M. C. B. couplers, based on the necessity of interchange of rolling stock between the steam and interurban roads. The requirements for interurban couplers formulated by last year's Committee, comprising the feature of a radial drawbar, provision for successful operation over irregularities of grades and

the limiting of lateral movement in the coupler heads, not only conflict with M. C. B. specifications, but offer to the interurban roads requiring these features, arguments which are brought into the question of the interchange of rolling stock with steam roads, as in the instance of the hauling of two steam railroad cars, coupled together, over the interurban lines, these cars being equipped with rigid M. C. B. couplers, in which the special features of radial drawbars, etc., are absent. Also, on the other hand, where the interurban car equipped with a radial drawbar is to be hauled by the steam railroad, the feature of locking the coupler in a central position to conform to M. C. B. requirements is hardly practical except in emergency cases.

Your Committee therefore feels that, so long as the specifications for couplers for interurban cars must embody the factor of intercoupling with M. C. B. couplers in order that rolling stock may be interchanged, only M. C. B. specifications for couplers and drawbars can be considered as a standard by this Association. The interurban roads contemplating the regular interchange of rolling stock with connecting steam railroads, other than those who are already doing so, will necessarily be obliged to arrange their trackage so as to permit of the operation of two or more steam railroad cars coupled together, and with this accomplished, there are no requirements of specifications other than the M. C. B.

The majority of interurban roads, however, as observation has revealed, generally operate their own rolling stock in trains, frequently cars from connecting interurban lines, occasionally a steam road car over their private right-of-way but seldom in city terminals, yet rarely if ever are their cars operated over a connecting steam road. This condition is regarded as typical and one which will exist until a time when increased business may bring about the regular interchange of rolling stock with steam roads, and under which conditions the interurban road or roads involved will have to conform to the current M. C. B. coupler practice and make such changes in their trackage as will permit of the use of these couplers.

While there are numerous operating disadvantages to the M. C. B. coupler in the radial form, for the interurban roads which may be classified under the conditions noted in the foregoing paragraph, your Committee feels that an M. C. B. radial coupler would best meet the requirements of the majority of interurban roads, in view of the occasional haulage of steam road cars and more particularly for the reason that the M. C. B. coupler head lends itself towards interchangeability of radial couplers, and therefore recommends as "Recommended Practice" the following specifications for M. C. B. Radial Couplers:

SPECIFICATIONS FOR COUPLERS FOR INTERURBAN CARS, WHERE THE INTERCHANGE OF EQUIPMENT IS INVOLVED.

1. All couplers must be made to automatically couple by impact, and to uncouple without the necessity of going between the cars, with M. C. B. and all other types of M. C. B contour couplers, whether used by steam or electric roads.

2. A device should be adopted for holding couplers on center within the required limits when inter-coupling with steam railroads.

3. An open knuckle for shackle bar connection should be used.

4. The draft gear, where possible, should meet M. C. B. requirements, and the draw-bar anchorages should be equivalent in strength to M. C. B. equipment and requirements.

5. Couplers must not uncouple when cars are being pushed around a curve of 35 ft. center radius.

6. There should be an arrangement to release and open the knuckle without requiring the operator to pass between the cars.

7. The face of the knuckle vertically should be 16 in. maximum.

8. The height of draw-bar center should be 31½ in. minimum and 34½ in. maximum above the head of the rail.

9. The coupling center of couplers must have a minimum projection of 6 in. beyond buffer faces at any point between the working limits of couplers.

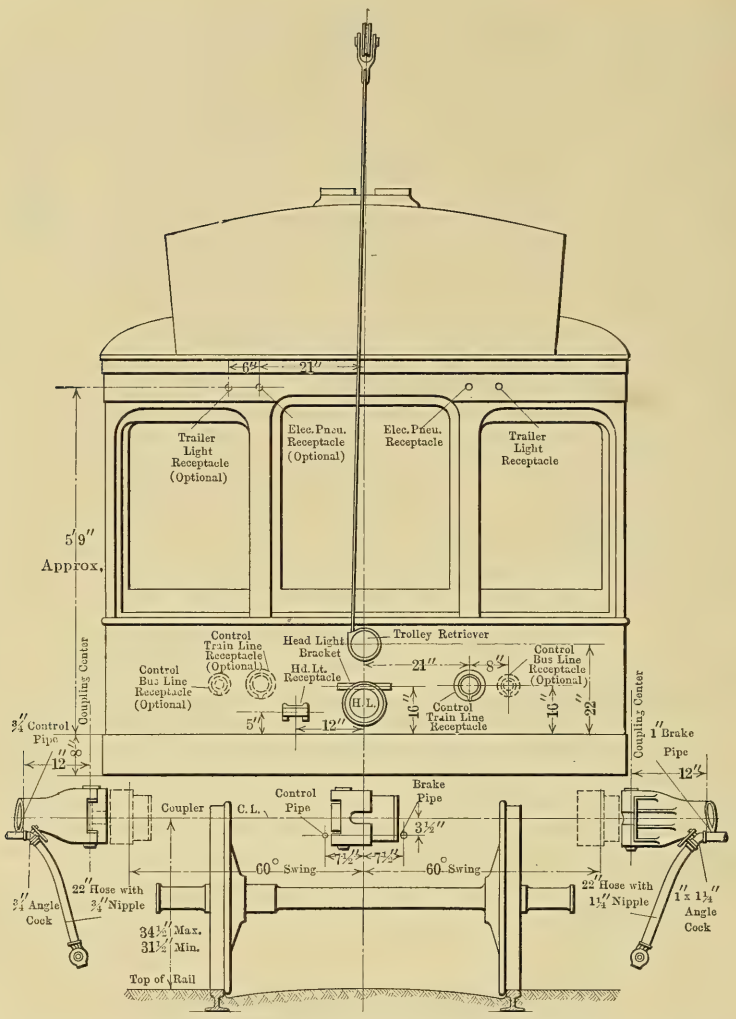
10. Couplers should be placed on both ends of the cars.

SPECIFICATIONS FOR THE END CONNECTIONS ON INTERURBAN CARS ENGAGED IN THE INTERCHANGE OF CARS

The subject of End Connections on Interurban cars was derived from the subject of Standard Air Signal and Control Connections which was assigned by the 1910–11 Executive Committee to last year's Committee on Equipment, which was unable to take up the question because of lack of time.

Data Sheets which were prepared and placed in the hands of Member Companies brought in a variety of arrangements, the majority of which were offered as suggestions for standard practice. A conference was held with the Committee on Heavy Electric Traction in New York on June 3, 1912.

Your Committee does not see the necessity for an Association Standard for elevated, subway or city cars, as there is hardly even a remote probability of these classes of rolling stock being interchanged over extended territories, and therefore the necessary standardization can be and in fact is usually agreed upon by the company or companies directly interested. Accordingly such work as has been accomplished has been directed toward interurban cars which are most frequently interchanged.



The location of control train and bus line electro-pneumatic and trailer light receptacles are such as to clear end doors where these are employed in the event conditions permit and if it is otherwise required, their position may be altered, but the relocation should be on the vertical center as shown.

The receptacles indicated by dotted outline are optional when not required, the trailer light receptacles are optional when bus lines are used. The headlight receptacles and bracket and trolley retriever bracket are optional when not required.

FIG. 6. SHOWING LOCATION OF PROPOSED STANDARD END CONNECTIONS FOR INTERURBAN CARS.

Due to the fact that the various types and forms of multiple-unit control are not now interchangeable, your Committee does not believe that the end connections alone can be standardized at the present time, and has therefore confined itself to a specification for air-brake connections and the location of all end connections for interurban cars. The recommendations of your Committee for "Recommended Practice" for interurban cars are shown in Fig. 6.

SPECIFICATIONS FOR SOLID STEEL WHEELS

The Subcommittee having this matter in charge held several meetings during the year, which may be briefly described as follows:

February 22, New York. Present: Messrs. E. W. Holst and H. A. Benedict. At this meeting comparison was made of the specifications drafted by the Committee on Equipment and that prepared by the American Society for Testing Materials. The specifications developed by your Committee were then presented to Mr. A. A. Stevenson, Chairman, Subcommittee on Steel Wheels. American Society for Testing Materials, and were also sent to member companies with requests for opinions, which opinions were subsequently tabulated.

March 28, New York. Present: Messrs. E. W. Holst, H. A. Benedict and H. Gulick. Mr. H. H. Adams and Secretary Litchfield also attended this meeting.

March 29 and 30. Joint meeting with the American Society for Testing Materials at Hotel Astor, New York. Present: Messrs. E. W. Holst and H. Gulick. Mr. H. H. Adams and Secretary Litchfield were also present.

April 19 and 20. Meeting with the general Committee on Equipment at Pittsburgh.

On June 3, joint meeting in Newark, N. J., Messrs W. A. Benedict, E. W. Holst, and C. Aertsen, chairman of the Special subcommittee appointed by the Wheel Committee of the American Society for Testing Materials, for special study of paragraphs 3 and 4 of which Mr. Benedict was a member.

June 14 and 15. Meeting with the general Committee on Equipment, Cedar Point, Ohio.

At each of these meetings the specifications were revised and the results are herewith presented. Owing to the fact that the material specifications are so closely interwoven with the design specifications, with special reference to tapes and gauges, and because of the lack of suitable facilities for hardening tests, it is recommended that these specifications go before the Convention as "Recommended Practice."

It is further recommended to the Convention that a Committee be appointed to reconsider the design specifications, with special reference to the contours, and to devise suitable designs for standard gauges and tapes; also to investigate the means for providing suitable instruments and methods of making physical tests that will determine the uniformity, hardness, etc.

The continuance of these specifications, which appear in full in Appendix B of this report, is also recommended.

SPECIFICATIONS FOR AXLES, SHAFTS AND SIMILAR PARTS

The Subcommittee having this subject assigned to them for consideration, have drawn up two sets of specifications covering Cold Rolled Steel Axles and Annealed Carbon Steel Axles, Shafts and Similar Parts, and have revised the specifications for Heat-Treated Carbon Steel Axles, Shafts and Similar Parts, the chief revision being a change in the phosphorous limits, which appear in full in Appendices C, D and E, respectively.

Recommendations

Your Committee respectfully recommends for adoption as "Recommended Practice" the following:

Specifications for Steel Wheels.
Couplers for Interurban Cars.
Specifications for End Connections on Interurban Cars.

For adoption as "Standard" we respectfully recommend the following:

Revised Specifications for Heat-Treated Axles, Shafts and Similar Parts, as reported by the Committee on Heavy Electric Traction in 1911.
Specifications for Cold Rolled Steel Axles.
Specifications for Ordinary Carbon Steel Axles.

Respectfully submitted,

F. R. Phillips, *Chairman.*
A. T. Clark,
E. W. Holst,
H. L. Patterson,
L. M. Clark,
E. D. Blair,
F. G. Grimshaw,
W. Thorn,
J. M. Bosenbury,
Committee on Equipment.

SUPPLEMENTARY REPORT OF COMMITTEE ON EQUIPMENT

To the Members of the Executive Committee of the American Electric Railway Engineering Association:

GENTLEMEN: — The Committee on Equipment for Nineteen-Twelve included in its report certain specifications for Cold Rolled Steel Axles, and Annealed Carbon Steel Axles, Shafts, and Similar Parts, which were recommended for adoption as Recommended Practice.

At a meeting of the Committee on Standards, August 13th and 14th, of this year, objection was raised to these specifications on the part of certain manufacturers, because of the sulphur limit, which was recommended as .04 per cent. rather than .05 per cent. which is the sulphur limit in the Association Specification for Heat Treated Axles, Shafts and Similar Parts.

It was maintained upon the part of the manufacturers' representatives at the meeting of the Committee on Standards that such a limitation would work great hardships upon the manufacturers, in fact, making the product of the steel commercially impracticable and the price prohibitive.

Objections on the part of the manufacturers were so insistent that the Committee on Standards adopted a resolution, referring these specifications back to the Committee on Equipment with the request that they prepare a supplementary report to the Executive Committee, revising these specifications by the insertion of a maximum limit of .05 per cent. in sulphur on check analysis.

In conformity with the resolution of the Committee on Standards the Committee on Equipment again took the matter under advisement and by a very close vote it was decided to accede to the demands of the manufacturers.

A great deal of thought and study was applied to the matter of sulphur content in axle steel since there is the tendency toward the belief that the presence of sulphur in quantities in excess of .04 per cent. is detrimental to the strength of the material, and in support of this statement we would quote from recognized authorities in these matters.

> * * * "We would state that our experience with steel running about .04 per cent. in sulphur or over is that it has a tendency to red-shortness and surface cracks and in some cases, developing a cokey condition. We have no trouble in securing material for this class of work (axles), analyzing .04 per cent. in sulphur or under. Where the sulphur content in steel is in excess of .04, some manufacturers offset the red-shortness condition by carrying a higher manganese, in some cases as high as .70. This will, to some extent, eliminate or absorb the detrimental effect of the high sulphur." * * *
>
> * * * "From such information as has been advanced in recent years as to the influence on structure of sulphide streaks and fissures, and a somewhat limited study of the same as applied to rail steel I would say that the acid or basic steel with a sul-

phur content of .04 per cent. or under will show when compared with a like steel of a higher sulphur content, less segregated sulphide and slag areas. Sulphur as sulphide of iron or sulphide of manganese, more particularly the latter, has strong tendencies toward accumulating small and scattered slag inclusions into larger areas and these larger areas furnish suitable conditions for the formation, under compression, of fissures leading to a final breakdown of the metal." * * *

* * * "When sulphur is high, .04 or higher, you get what is known as red-shortness which causes brittleness and the steel is apt to produce flaws. The lower the sulphur content within reason that can be obtained the better steel you are getting." * * *

The above are illustrative of the opinions of many metallurgists and users of steel for axle and wheel purposes. On the other hand, some engineers are skeptical as to the influence of a high sulphur content such as .05 per cent. upon the structure of the steel for axle purposes, as is indicated by the following extracts from opinions upon this subject:

* * * "We do not recognize that sulphur is the chemical constituent which should be watched as closely in the axle material as some other elements and do not place any rejection on sulphur although we express a desire for the sulphur around .04 per cent." * * *

* * * "We do not believe that much improvement could be made in the steel in going from .05 per cent. to .04 per cent., although in our driving axles we hold it to .04 per cent. However we believe that steel within either of the above limits will not be red short or hot short. A number of people who draw up specifications leave out the sulphur requirement altogether, claiming that if the steel is properly worked the sulphur content is sufficient. However, I have never agreed to this proposition and think that the sulphur should be limited within reason." * * *

* * * "It is not impossible to secure .04 per cent. sulphur in steel commercially, but it is more difficult and expensive for the reason that a better grade of scrap is necessary and this is true more in the acid process than in the basic process, although in either process it is more expensive than .05 per cent." * * *

From the above it will be seen that a difference of opinion exists regarding the effects of sulphur upon the structure of steel; still the tendency is toward limiting the same to .04 per cent. However, as is indicated in a statement from one prominent engineer, there is not extant sufficient dependable data upon which could be based a decided opinion proving the deleterious effect of a sulphur content in excess of .04 per cent., and, upon reconsideration of this matter by the Committee on Equipment, we feel that perhaps the time is not opportune for insisting upon a limit of .04 per cent. in sulphur, and you will therefore find attached revised specifications for Cold Rolled Steel and Annealed Carbon Steel Axles.*

Respectfully submitted,

F. R. PHILLIPS, *Chairman.*

* The specifications, as originally drawn up by the Committee, together with the revisions and recommendations in this supplementary report are shown on pages 772 to 778.—ED.

APPENDIX A

SELF-PROPELLED CARS

Paper prepared by Messrs. Holst, Bosenbury and Thorn

The intimate relation between railway facilities and the opening of undeveloped sections of country is beyond dispute. In these days, however, the public has become so accustomed to ample railway service that frequent trains and rapid service are demanded even for sparsely populated districts. In order to fill this want it has been necessary to look to the self-propelled car as the only means which would satisfy these requirements for a minimum investment.

It is the intention of this paper chiefly to cover the historical development of the several types of self-propelled vehicles intended to run on rails. A brief description will be presented of a few of the radically different types and, while operating costs will be given, no attempt will be made to reduce the latter to a common basis. In addition to this general review, some noteworthy modern American installations of self-propelled cars will be described at length.

The subject of self-propelled motor cars is not a new one, as in Europe work has been done along these lines with more or less interruption for the past sixty years. Nevertheless, the systematic development of the motor car did not begin until 1897. From about 1901 onward its growth has been phenomenal both in this country and abroad. The pioneers in this field used steam, compressed air and the storage battery, although in 1884 a nitrate of soda locomotive was used successfully for six months in France, and about the same time a successful trial was made with a locomotive which used superheated water under pressure. The more recent developments have been along the line of steam-electric, gasoline-electric and straight gasoline cars, in addition to which improved forms of the storage batteries have also been exploited.

The several types of self-propelled cars will be taken up as follows:

(*a*) Steam.
(*b*) Compressed air.
(*c*) Storage battery.
(*d*) Gasoline-direct driven cars.
(*e*) Steam-electric and gasoline-electric.

SUMMARY

The early experimentors with self-propelled cars used steam as a motive power. The first steam motor car was built in England in 1847. Among those which followed were the Peebles, Ganz, Purret, Serpollet and the Kourarets. The costs of operating early steam systems varied from 5 to 20 cents per car mile. It is probable that these costs were for operation only, no allowance being made for interest on investment or depreciation.

The first application of compressed air to motor cars was made on the Second Avenue Railroad, New York, in 1879. Shortly after, the Mekarski system appeared in France, followed by the Hardie and Hoadley-Knight systems in America. The average costs for these systems seem to have been about 18 cents per car mile.

France in 1880 and Germany in 1885 were the earliest to apply storage batteries to moving vehicles. The Waddell-Entz, Hagen, Fauré, Chloride, Gould, Exide and Edison batteries were the more important types used. The operating costs of the storage battery cars ranged from 5 to 19 cents per car mile.

The first gasoline-motor car appears to have been operated in Wurtemburg, Germany, in 1893. In 1899 a similar type was produced in Chicago by the Hydro-Carbon Company. The first McKeen car was operated in 1901. Other types of gasoline-motor cars are the Wolsely, Daimler, Stover and Fairbanks-Morse. The operating costs of these cars have been approximately 16 cents per car mile, although the cost has run as high as 30 cents per train mile where exceptionally heavy cars have been used with trailers.

Apparently the first gasoline-electric car was produced by the Patten Motor Car Company in the United States in 1890. Steam-electric cars were tried on French and English roads about the same time. The first extensive installation of gasoline-electric cars, however, was not made until 1902 when the Arad Csanad Railway, Hungary, was equipped by the French Westinghouse Company. During the latter year, the General Electric and Strang cars were developed in the United States. The average operating cost of gasoline-electric cars has varied from 11.3 to 17 cents per car mile.

A — STEAM CARS

The first recorded combination of the steam locomotive and passenger coach is the "Fairfield" which was built in 1847 by the Great Eastern Counties Railroad, England. In the following year the same company constructed the "Enfield," a car similar to the "Fairfield" but with a baggage compartment in addition. After two or three years' use these cars were superseded by light locomotives, as the tendency was to use independent locomotives with trailers as soon as the traffic justified it. It is noteworthy that the

modern practice of the English steam railways follows parallel lines, that is, the motor cars are introduced only on light traffic divisions where train service with an equally good headway would be unprofitable. The "Fairfield" was 12 ft. 6 in. long with space for seven passengers. It had a vertical boiler, burning coke or coal for fuel, and its engine was mounted on the same truck. The "Enfield" accommodated 16 passengers.

In 1848, the Great Western Railroad of England built a combined locomotive and passenger car 39 ft. long with an open and closed saloon, seating 48 passengers. The equipment was similar to that of the "Fairfield" but was built for a 7 ft. gauge.

Except for some experiments on self-propelled steam cars in 1873, practically no further work was done in Europe until 1897. The latter year saw the installation of the first steam self-propelled car in the United States, the same being tried by the New England Railroad and the Erie Railroad. The notable feature of this car, which was built by the Schenectady Locomotive Works, was that it endeavored to rival heavy electric service, inasmuch as it was built for a maximum speed of 50 m. p. h. and seated approximately 45 passengers. This car carried a vertical boiler, designed for 250 lb. pressure, which was mounted on the same truck with the engine.

The revival of the steam car in England began in 1903 when the London & Southwestern Railroad put out the first of the more modern designs. It was followed by the Lancashire & Yorkshire Railroad, the Great Western Railroad and the Taff Vale Railroad. All of these companies built their own cars along similar designs. The London & Southwestern car, which was 50 ft. long and seated 40 passengers, was used on the Fraton & South Sea Division. This car had a vertical boiler and engine mounted on the forward truck, the engine driving the leading wheels. This equipment was found to be economical for the slow speed and low acceleration conditions for which it was designed. The Taff Vale car was 70 ft. long, weighed 42 tons and seated 43 passengers. It was constructed for a speed of 35 m. p. h. All of the equipment of this car was suspended on an independent power truck. The boiler was of special horizontal type, carrying 180 lb. of steam. The Lancashire & Yorkshire cars were similar to the Taff Vale design, but were notable in being the first to use coupled drivers. The Great Western car, which was the largest of all, ran on the Stroud Valley Division. This car was built for a maximum speed of 55 m. p. h. and made approximately 200 miles a day. The boiler was of the vertical type and a two cylinder engine with coupled drivers was used. This car was light, easy to control, had reasonable speed and acceleration and low maintenance expense. Its first cost was

approximately $9,000. This design was found to be so satisfactory that by 1905 the company had 60 of these cars in service and several others in process of construction.

About the same period, Serpollet steam cars were operated on the Paris, Lyons & Mediterranean Railroad of France, and on the Swiss Federal Railroads, both contemporary with the Purret system in France, and that of the Belgium State Railways, the Kourarets system in Austria and the Ganz system in Hungary.

These continental types were all approximately 60 ft. long and weighed about 35 tons. The Purret cars had a tubular boiler in which the water was superheated, and a four cylinder tandem-compound 260 hp. engine, chain-driven to the rear axle of the power truck, which had a wheel base of 10 ft. 6 in. The rear truck consisted of a single axle. The intended speed was 56 m. p. h. The Belgian State Railways used cars of their own make equipped with a flash-type boiler. This boiler proved very unsatisfactory on account of tube troubles. The most satisfactory foreign type, apparently, was the Kourarets system, which showed a very low operating cost per car mile compared with other European designs. The equipment of these cars included a two cylinder cross-compound engine supplied with superheated steam. The cars were 50 ft. long, having passenger and baggage compartments and weighed only 20 tons. The Ganz cars were designed to operate at 35 m. p. h. They were equipped with a two cylinder, cross-compound, clutch-driven engine, built in 35, 50 and 80 hp. sizes. These cars appear to have been unsuccessful on account of the complexity of the equipment and the poor quality of water obtainable.

In the United States, the year 1905 saw steam cars in use on many railroads, among them the Union Pacific; Delaware & Hudson; Lake Shore & Michigan Southern; Delaware, Lackawanna & Western; Erie, etc. The cars on most of these roads weighed from 40 to 50 tons and averaged about 56 ft. in length. The equipment usually consisted of water-tube boilers designed for 200 to 300 lb. pressure, which supplied dry steam to simple two cylinder engines of from 35 to 50 hp. and capable of driving the cars at speeds ranging from 35 to 60 m. p. h.

The Chicago, Rock Island & Pacific Railway used two types of a steam motor car, developed by the Baldwin Locomotive Works, along the lines of the improved Ganz car. Each car weighed approximately 50 tons and had a capacity of 250 hp. One burned coal and the other oil, and both were capable of making 50 m. p. h. or more on level track.

In 1905 also the Peebles car was introduced extensively in Great Britain. The equipment consisted of water-tube boilers and two cylinder, cross-compound engines connected to the axles by

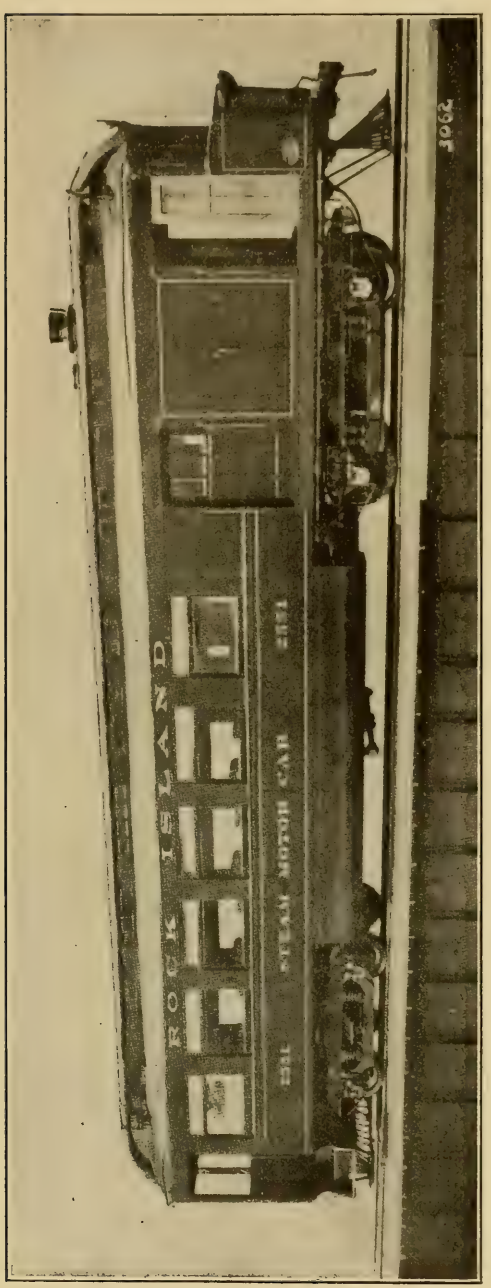


FIG. 1. ROCK ISLAND STEAM MOTOR CAR NO. 2551.

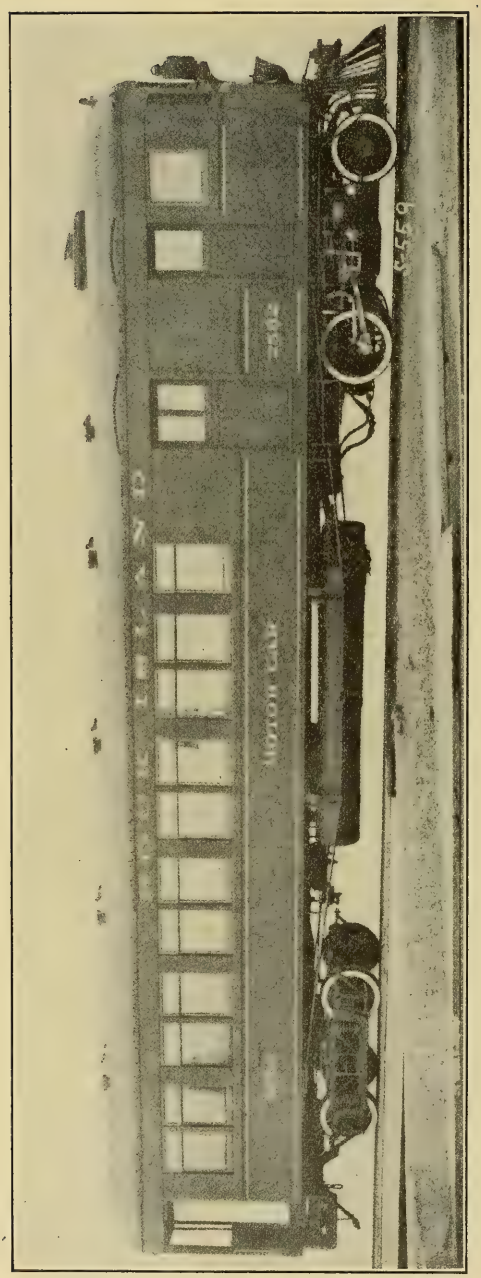


Fig. 2. Rock Island Motor Car No. 2552.

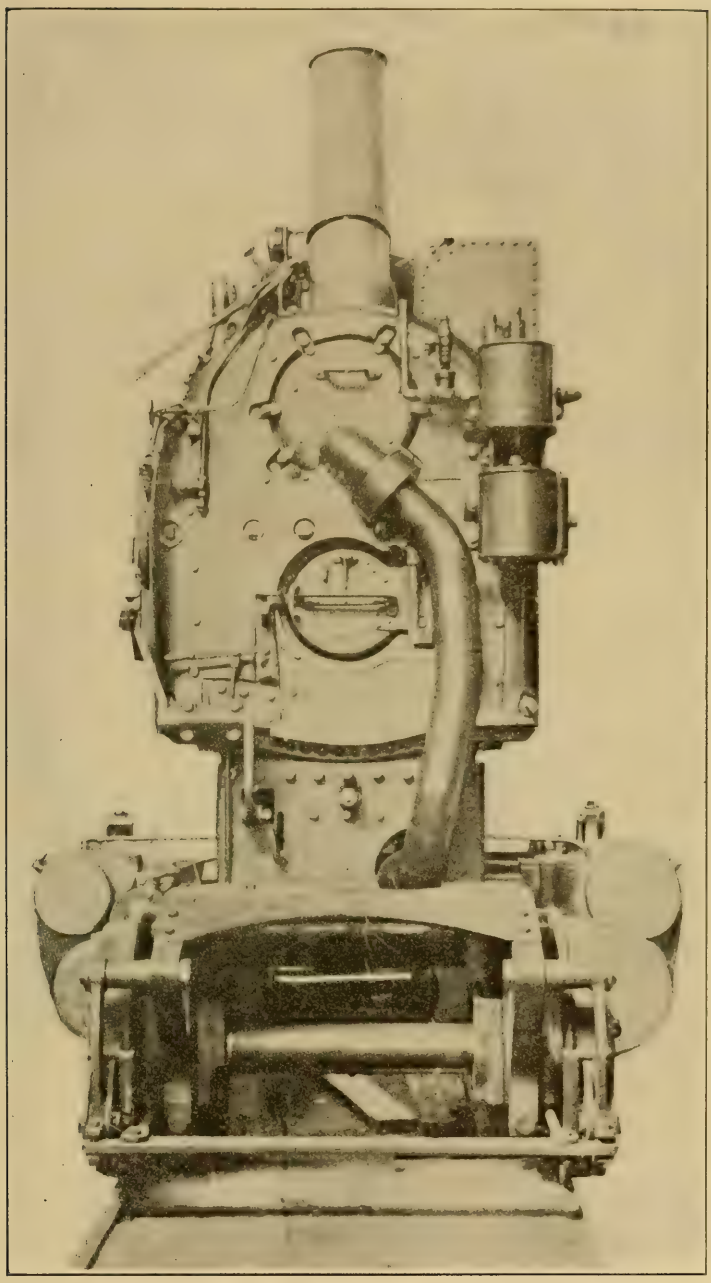


FIG. 3. VIEW OF BOILER AND ENGINE, ROCK ISLAND NO. 2552.

clutch and gears. It is of interest to note that this was the first system to steam jacket the engines for the sake of economy.

From the data obtainable, it is almost impossible to compute operating costs upon any reasonable basis of comparison owing largely to the advance in wages and costs of materials. The following Table I clearly shows the great range in operating costs per car mile on six European railway systems, two of which use steam locomotives:

TABLE I — OPERATING COSTS ON SIX EUROPEAN RAILWAYS.

NAME OF ROAD	Length of road in miles	Operating cost per car mile	Remarks
Geneva Suburban	40.0	13.2	Steam locomotive.
Mulhouse City	18.0	17.8	Steam locomotive.
Paris Suburban	6.2	20.0	Ganz steam car.
Paris and Orleans	———	7.0	Purret system.
Austrian State	———	5.0	Kourarets system.
Hungarian State	———	———	Ganz system.

B — COMPRESSED-AIR CARS.

The first authentic report available on the use of compressed-air, self-propelled cars is that referring to the installation made on the Second Avenue Railroad, New York, in 1879. The equipment comprised the Hardie system, in which air was stored at 2,500 lb. pressure and supplied through a reducing valve at 300 to 400 lb. pressure to the engine which was direct-connected to the wheels.

The next work along this line appears to have been done in France in 1884.

In the year 1891, the Mekarski system had been developed on the Nantes & Paris line in France to such an extent that 26 additional cars were ordered. In this case the air was stored at 600 lb. pressure and supplied directly to the motors on the basis of isothermal expansion. The cars were designed to run at 8.5 m. p. h. In 1892, the same system was applied on cars in Berne, Switzerland, excepting that the air was stored and used at 440 lb. pressure.

Meanwhile, similar work was being done in the United States. In 1891, the Toledo (Ohio) Consolidated Street Railway conducted several experiments. The Anaconda Mining Company also interested itself in the compressed-air locomotive. The use of compressed air for locomotion commended itself particularly to places where fire or sparks of any kind were conducive to danger, as in mines and cotton or powder mills. This lead to the installation, from 1904 to 1909, of several pneumatic locomotives which were successfully operated from an economical standpoint.

In 1896 two Hardie cars were installed on the 125th Street line in New York. This system was a modification of the earlier one, inasmuch as the air was passed through a reducing valve, then through an auxiliary valve at motor pressure and reheated before being passed to the motors. The reheating was done to obtain, if possible, an isothermal expansion which would increase the efficiency.

In 1897, a Hoadley-Knight car was placed in service on the Twenty-eighth and Twenty-ninth Street line, where it gave efficient

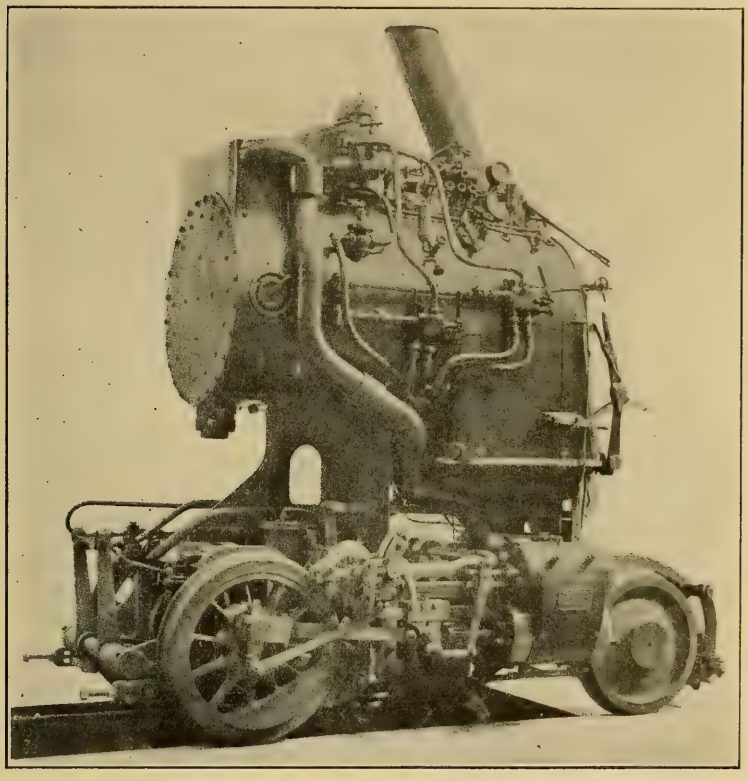


FIG. 4. VIEW OF BOILER AND ENGINE, ROCK ISLAND NO. 2552.

and successful service for two years. This system used a compound engine in which the high-pressure cylinders were connected to one axle and the low-pressure cylinders to the other. The air was stored at 2,400 lb. pressure and used at 320 lb. pressure at the motors. The complete car weighed 18,750 lb. The maintenance

of approximately 2.5 cents per car mile compared favorably with electrical equipment of that period.

About the same time the Metropolitan Street Railway, New York, tried the Hoadley-Knight system on its Lenox Avenue line with the result that in 1899 twenty cars with this equipment were installed on the Twenty-eighth and Twenty-ninth Street crosstown line.

The following year, however, all Hoadley-Knight motors were replaced by Hardie motors, the former having proved unsatisfactory. Three of the 1896 type Hardie motor cars were taken to Chicago where they were used successfully for five years. During 1901, also, the Rome (N. Y.) City Street Railway made successful use of the Hardie motors.

The available data on operating costs of air motor systems are very meagre. Reliable information has been obtained only on the Mekarski system as used on the Nantes & Paris Railway. This line is 1.86 miles long and was built at an original outlay of $92,000, or $48,960 per mile. In 1891 it operated 300 car miles per day to carry 3,140 passengers. The gross receipts were 21.4 cents per car mile of which 83 per cent. was required for the operating expenses, divided as follows:

Operating Expenses on Nantes & Paris Railway.

Operating Account	Cents per car-mile
Administration	1.41
Maintenance of line	0.66
Traffic	3.00
Motive power	11.74
Sundries	0.96
Total operating expenses	17.77
The motive power expense was divided as follows:	
Wages ($20)	5.86
Turbine power, oil, fuel, etc., per hp	3.72
Maintenance and renewals	1.86
Sundries	0.30
Total motive power expense	11.74

C — Storage Battery Cars.

As early as 1880 a locomotive with the Fauré accumulator was used at Brueil, France. The first accumulator car, however, did not appear until 1885, in which year Reckenzaun placed a 2.5 ton car in operation. Experiments made in Brussels, Belgium, on this type of car in 1880 were so successful that during the following two years 900 cars were placed in service. The first early American

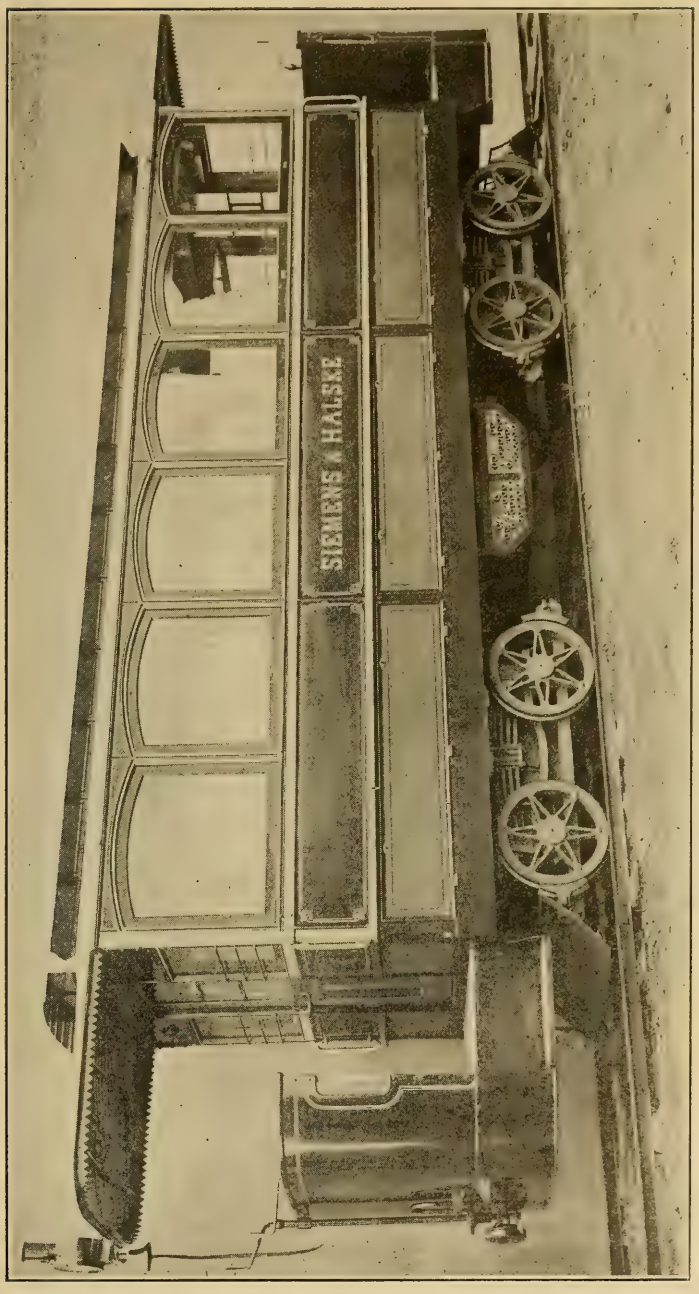


FIG. 5. SIEMENS & HALSKE STORAGE BATTERY CAR.

work worthy of note occurred in 1889 when ten cars of the Madison Avenue line in New York were equipped with Julien cells. These cars were abandoned after several months' operation.

Considerable activity was manifested in storage batteries for the next few years, but the greatest progress seems to have been made in the United States and Germany.

The storage battery experiments made in Birmingham, England, appear to have been very unsuccessful, as a statement issued in 1897 showed operating expenses at 41 cents per car mile as against receipts of 31.4 cents per car mile. Nevertheless, a storage battery line in Hanover, Germany, operated during the same year, showed running costs which were but slightly in excess of that of the ordinary trolley car.

The experience with storage battery cars in Germany was so uniformly satisfying that in 1905 the Prussian-Hessian State Railroads put into service 27 twin-body cars, each seating 100 people. This was the inauguration of a policy to supply self-contained electric cars for light traffic lines which are operated out of cities where electrical energy can be purchased at a reasonable cost.

In 1908 the Prussian equipment was increased by 57 two-motor cars, each weighing 33.5 tons and seating 70 passengers. During the same year 19 additional cars were distributed on four lines to act as feeders for the main line. The usual equipment of these cars consisted of two 50 hp. series interpole motors driven by current from a 368 ampere hour battery (which is placed under the seats) at a maximum speed of 31 m. p. h. The next battery cars were some steam coaches, which were converted in 1907. These cars, with the battery under the seats, weighed 35.2 tons and were driven by two 50 hp. motors over a 37 mile road. The car covered 100 miles a day. Thirty-three more ordered in 1909 were 34 ft. long, 9 ft. 10 in. wide, weighed 66 tons, and were designed for a maximum speed of 31 m. p. h. and a maximum acceleration of 0.56 m. p. h. p. s. The equipment consisted of a standard 368 amphere hour battery and two 80 hp. motors. It might be mentioned here that the Prussian-Hessian State Railroads have also done some experimenting with shunt wound motors and with gasoline-electric cars.

Among early experiments in the United States was the Waddell–Entz system, which was tried in Philadelphia during 1891. The battery was of the alkaline electrolyte type with iron and porous copper for electrodes. It was an early attempt to secure a durable, light-weight battery. In 1895 the chloride accumulator was tried on two cars on the Madison Avenue line. These cars were 18 ft. long and were driven by GE-800 motors which were supplied by a 400 ampere-hour accumulator suspended on the truck

between the axles. This installation seems to be the first where the battery was suspended from the truck, thus removing the objection of inaccessibility and trouble from fumes which were given in the earlier cars where the batteries were stored beneath the seats. In 1897, the Englewood & Chicago Railroad built a 12 mile level line between Blue Island and Chicago. The twenty cars for this road were 30 ft. long, seated 28 passengers and weighed 13.5 tons.

Fig. 6. Third Avenue Storage Battery Car.

The equipment consisted of two 50 hp. motors and chloride accumulators suspended beneath the car. It was reported that after 8,000 miles of service the battery was still in good condition.

The work of the Third Avenue Railway Co., New York, since 1910 is so extensive that it will be described at length in a monograph. It is noteworthy that when this company undertook to install storage batteries it succeeded in securing a maintenance cost per mile guarantee from the storage battery maker.

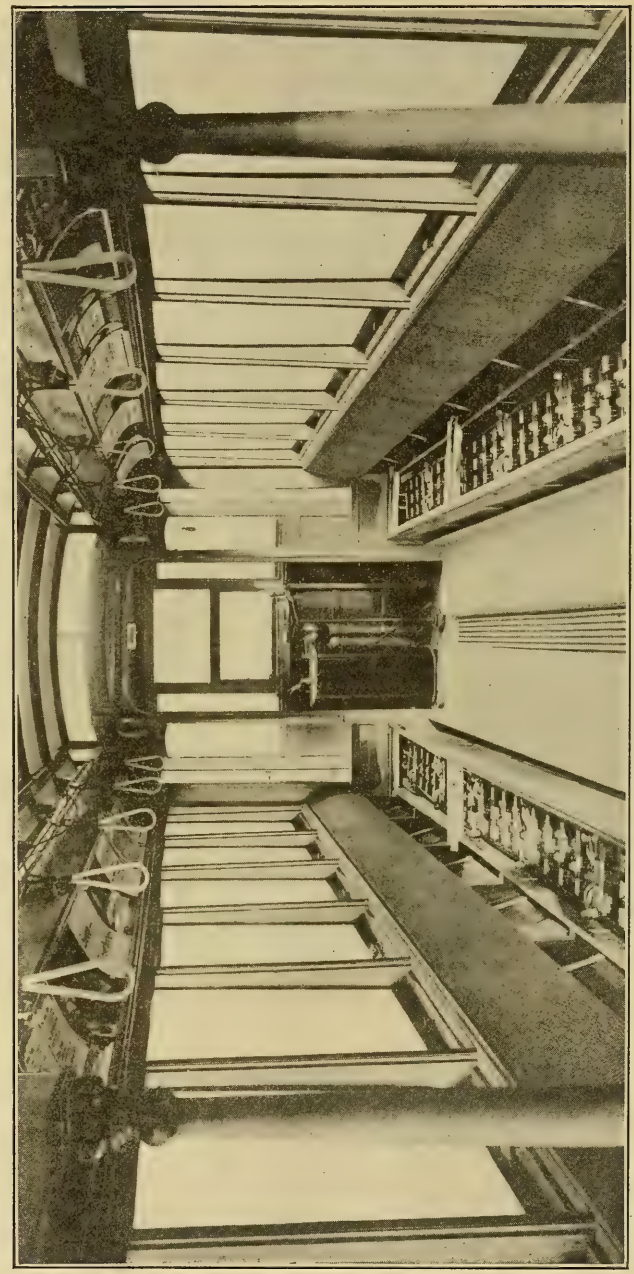


FIG. 7. INTERIOR VIEW OF THIRD AVENUE STORAGE BATTERY CAR.

The next milestone in the progress of the battery car was brought about by the invention of the Edison cell, which makes a successful durable, light-weight battery. This battery is of the alkaline electrolyte type, with iron and nickel for electrodes. The first Edison-Beach car equipped with these batteries was tried in 1910 on the Twenty-eighth and Twenty-ninth Street crosstown line in New York, but was removed when the Third Avenue Railroad made an agreement to operate that property with its own storage battery cars. The Edison-Beach cars, however, are now in use on many large traffic lines and at the present time the company which builds these cars is even constructing a switching locomotive which is to be used in a steam railroad yard at Cincinnati. Among the railroads now operating Edison-Beach cars are the following:

Chicago & Great Western Railroad,
Chesapeake & Ohio Railway,
Cambria & Indiana Railroad,
United Railways of Cuba,
Milton & Watsontown Railroad,
Ephrata (Pa.) & Lebanon Street Railway,
Washington (D. C.) Spa Springs & Gretta Railroad,
Carolina Traction Company, Rock Valley, S. C.,
Charlotte (N. C.) Rapid Transit Company,
Salisbury & Spencer Railway Company, Concord, N. C.,
Suffolk Traction Company, Patchogue, N. Y.,
New Castle (Del.) & Delaware City Traction Co.

The accompanying Table II shows in detail the operating costs of five lines equipped with Edison-Beach cars. It is seen that the performance varies from 110 to 182 miles a day and the schedule from 8.13 to 19.2 m. p. h. The watt-hour efficiency of the battery is 44.3 per cent. Taking the average energy purchased per car mile as 1.438 kw-hours, the cost would be 1.78 cents per car mile; on the other hand, the average requirements for the lead battery is only one kw-hour per car mile, which upon the same basis would lead to a cost of 1.25 cents per car mile for the purchase of electrical energy. The maintenance of the Edison battery, assuming a life of seven years, is, however, only 0.5 cents per car mile compared with a parallel charge of 3 to 4 cents per car mile for the lead battery. Experience with electric trucks indicates a maintenance cost of 0.31 cents per truck mile for Edison batteries and 4.12 cents per truck mile for lead batteries.

TABLE II — SHOWING OPERATING DETAILS FOR STORAGE BATTERY CARS.

ROAD	Length in miles	Miles operated per day each	Schedule M. P. H.	Miles per charge	Amp.-hours per car-mile	Kw-hours per car-mile	Kw-hours per car-mile bought	Number cars
New Castle & Delaware City	9.60	182.0	19.20	40.0	2.70	0.650	1.569	*1
Carolina Traction Company.	2.71	110.0	8.13	30.0	4.39	0.527	1.250	2
Charlotte Rapid Transit Company	3.60	111.0	10.80	14.0	4.33	0.520	1.400	2
Salisbury & Spencer	1.50	99.0	9.00	10.0	4.24	0.509	1.370	1
Washington Spa Springs & Gretta	2.50	144.0	15.00	20.0	3.50	0.504	1.600	
Average	3.98	129.2	12.43	22.8	3.83	0.542	1.438	

* This is a 4-motor car.

Watt-hour efficiency of battery ..... 44.3 per cent.
Watt-hour efficiency of battery-car system (assuming 15 per cent. loss in charging system) ..... 37.7 per cent.
Edison 1.438 kw-hours per car mile cost ..... 1.78 cents.
Lead 1.000 kw-hours per car mile cost ..... 1.25 cents.

COMPARATIVE PERFORMANCES OF EDISON AND LEAD BATTERIES IN RAILWAY SERVICE.

BATTERY CARS	Edison batteries	Lead batteries
Average miles run per car a day*	51.400	61.900
Kw-hours per car mile, used at motors	0.603	0.507
Kw-hours per car mile, purchased	1.910	0.973
Kw-hours per car mile, battery input	1.480	0.853
Ampere-hours per car mile of charge	0.870	5.520
Ampere-hours per car mile of discharge	5.000	4.530
Ampere-hours efficiency of battery, per cent	57.500	82.000
Voltage efficiency of battery, per cent	71.000	72.700
Watt-hour efficiency of battery, per cent	40.800	59.600

* These figures are averages taken from service conditions, and do not represent the full mileage on one charge.

Of the foregoing installations the Ephrata & Lebanon Street Railway is of particular interest. It is 22 miles long with 5.7 per cent. grade and is operated with a 35 ft. combination car, seating

Table III — Data on Storage Battery Cars of All Types.

Name of Road	Type of cell	Weight of car in tons	Seating capacity	Number and H. P. of motors	Schedule speed M. P. H. (max.)	Energy in watt-hours	Miles per charge	Energy cost (cents)	Renewal of plates (cents)	Battery maintenance (cents)	Station superintendents (cents)	Station attendants (cents per car mile)	Lubrication (cents)	Car maintenance (cents)	Total (cents)	Battery capacity, ampere-hours
Italian roads (average for car and trailer)	Fauré	.....	.....	.....	.....	.....	.....	0.076 T. M...	0.146 T. M...	0.089 T. M...	3.27 T. M....	0.736	0.288 T. M.....	1.14 T. M....	5.83 T. M....	.....
Prussian state	Hagen	33.5	70	2–50	31.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	368
Prussian government	Hagen	66.0	82	2–80	31.00	32 T. M.....	31.0	.....	.....	.....	.....	.....	.....	.....	19.00 T. R. M.	368
Prussian government	Hagen	35.2	.....	2–50	31.00	57 T. M.....	37.0	.....	.....	.....	.....	.....	.....	.....	.....	368
Foyers, France	.....	9.4	30	.....	.....	645 C. M.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	368
Halle, Germany	Hagen	60.5	.....	.....	33.25	24.2 T. M....	62.5	.....	.....	.....	.....	.....	0.200 C. M.....	0.75 C. M....	9.34 C. M....	350
Second Avenue Line, N. Y.*	Waddell	.....	.....	.....	.....	.....	.....	.....	0.300 C. M...	2.29 C. M....	6.29 C. M....	.....	.....	.....	.....	.....
Second Avenue Line, N. Y.*	Entz	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28th & 29th Sts., N. Y.	Gould	7.0	28	4	.....	629 C. M.....	125.0	.....	.....	.....	.....	.....	.....	.....	.....	520
28th & 29th Sts., N. Y.	Exide	7.0	28	4	.....	629 C. M.....	100.0	.....	.....	3.500 C. M...	.....	.....	.....	.....	.....	420
Suffolk Traction Co.	Edison S. T.	7.0	.....	2	.....	63.4 T. M....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28th & 29th Sts., N. Y.	Edison S. T.	5.0	26	2–5	15.00	853 C. M.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28th & 29th Sts., N. Y.	Edison D. T.	16.8	.. ..	4–5	20.00	43.8 T. M....	13.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
28th & 29th Sts., N. Y.	Edison D. T.	14.5	40	.....	35.00	650 C. M.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28th & 29th Sts., N. Y.	Edison D. T.	9.0	45	4–5	35.00	.....	85.0	.....	.....	1.800 C. M...	.....	.....	.....	.....	.....	.....
Ephrata & Lebanon	Edison D. T.	.....	24	.....	25.00	.....	80.0	.....	.....	0.200 C. M...	.....	.....	.....	.....	.....	.....
Montandon, Penn.	Edison D. T.	.....	.....	.....	.....	.....	.....	3.300 C. M...	.....	.....	.....	a5.67	.....	1.43 C. M....	10.63 T. M...	.....
Third Avenue, N. Y.	Lead	7.0	26	2 G. E.–1022	15.00	.....	119.0	1.000 C. M...	.....	3–4 C. M.....	.....	.....	0.00014 C. M...	.....	†14.14 C. M..	.....
Englewood & Chicago R. R.	Chloride	13.5	28	2–50	12.00	1250 C. M....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Paris *b*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.00 C. M...	.....

* Average figures for 3 months operation of 10 cars. † See Monograph on Third Avenue Railway. *a* Platform expenses. *b* Average for accumulator cars in 1910 and 1911. C. M.= Per car mile. T. M.= Per ton mile. T. R. M.= Per train mile. S. T.= Single truck. D. T.= Double truck.

24 passengers. This car, which makes 22 trips a day, replaced a steam locomotive and two coaches, which made only two trips a day. The battery was guaranteed for four years by the manufacturer. A single charge is sufficient to drive the car 80 miles on a level at a maximum speed of 25 m. p. h. The wheels on the Ephrata & Lebanon car have ball bearings and are driven independently. It is asserted that the latter feature saves about 25 per cent. in energy consumption. It is interesting to note that this car has kept up its work in heavy snow at a temperature of 20 deg. (Fahr.) below zero.

The Edison-Beach car is made for both single and double trucks. The single-truck car is 18 ft. long and weighs approximately five tons. The equipment consists of 200 A4 or A8 cells and two 5 hp., 110 volt motors to drive the car at 15 m. p. h. maximum speed. These motors take 3.5 kw. in starting and 1.5 kw. when propelling car along the level. The double-truck car is 28 ft. long, seats 45 and weighs nine tons. Its equipment consists of 190 A6 Edison cells and four 5 hp., 85 volt motors, which drive the car at a maximum speed of 35 m. p. h.

An important point in the design of storage battery cars is the necessity for low weight. This is indicated by the following comparison of the weights per seated passenger in various types of steam and electric cars.

Weight Per Seated Passenger.

Type of Cars	Pounds
Average Pullman car	3000
Steam day coach	1500
Steam suburban coach	1100
Single-truck trolley car	800
Double-truck trolley car	1000
Double-truck Edison-Beach car	600
Single-truck Edison-Beach car	380

Another feature of design, especially pertinent in storage battery cars, is the necessity for incorporating efficient anti-friction bearings so that the energy consumption will not be excessive.

Furthermore, if high speed work is attempted the car body should be designed to minimize the resistance of the air.

The data for the several types of storage battery cars mentioned are given in Table III.

D — Gasoline-Electric and Steam-Electric Cars.

The first gasoline-electric car in the United States appears to have been made by the Patton Motor Car Company which successfully used such a car on a Chicago suburban road in 1890. This car weighed 11 tons, was equipped with an 18 hp. engine direct-connected to a 12 kw. generator which in turn supplied current to a single 35 hp. motor. A battery auxiliary of 150 ampere-hour capacity served to assist the generator during acceleration and to supply light. Seven years later the same company built a 16 ft. car which weighed 13 tons complete. The equipment consisted of a 25 hp. engine direct-connected to a 15 kw., 220 volt generator which supplied two 35 hp. motors. As in the former car, an auxiliary battery of 200 ampere-hours capacity was supplied. This car was designed for a maximum speed of 40 m. p. h. when coupled to an 18 ton trailer.

Fig. 8. Petrol-Electric Motor Car of 55 Hp. on Ostdentsche Eisenbahn Gesellschaft.

Following closely upon this development, the French Westinghouse Company conducted some experiments as a result of which it equipped the Arad Csanad Railway in Hungary with the first gasoline-electric cars ever installed in Europe. Previous to 1902, this railway was in poor financial condition owing to the operation of steam trains through sparsely populated sections. The adoption of the gasoline-electric car not only enabled the railway to use lighter trucks, to reduce operating expenses, to furnish more frequent service, but also to make a considerable reduction in rates

of fare. The service of the company was trebled and its annual profits increased 83 per cent. during the following seven years.

The year 1909 showed a net profit of approximately $100,000 notwithstanding the fact that the entire system was not completely electrified until 1907 at a total expense of approximately $405,200, that the wages of the employees increased sensibly and that the price of gasoline advanced 25 per cent. The Westinghouse and Weitzer systems were adopted after the company had tried several other types of self-propelled cars. This railway now has one 40 hp. gasoline car, four 50 hp. gasoline-electric cars, and fourteen 70 hp. gasoline-electric cars, the whole covering a network of 290 miles of lightly populated country.

FIG. 9. PETROL-ELECTRIC MOTOR CAR OF 55 HP. ON OSTDENTSCHE EISENBAHN GESELLSCHAFT.

All cars on this line weigh not more than 25.5 metric tons and are designed to give not more than 25 m. p. h. at maximum speed. The Westinghouse equipment consists of four cylinder, four cycle, gasoline engines, direct-connected to a d. c. generator, all bolted to the same bed and placed within the car over one truck. The speed control is effected by throttle, field and series-parallel connection of the motors. The Weitzer system of control seems identical with the foregoing, differing only in size of unit.

Contemporary with the French Westinghouse work, the General Electric Company and William B. Strang began experimenting simultaneously with the gasoline-electric car in this country. During this experimental period the General Electric Company built three cars which differed only as to size and method of control.

The first car which closely resembled a standard railway coach was 65 ft. long, 9 ft. 8 in. wide and was divided into engine, baggage, smoking compartments and main saloon. This car weighed 68 tons and seated forty passengers. The power plant consisted of a six-cylinder, horizontally opposed 140 hp. Woolesley engine and was started by the explosion of a powder cartridge into one of the cylinders. The engine was direct-connected to a 600 volt generator which was excited by a 125 volt chain-driven exciter. Current at variable voltage was supplied to 2 GE-69 motors.

The second car was all steel, 49 ft. long, 8 ft. 8 in. wide. It weighed 31 tons, divided like the first, with a seating capacity of 45, but unlike the first, it was provided for single-end, only. The engine for this was an eight cylinder, vertical type, 200 hp. machine, direct-connected to a 600 volt generator. The motors and control were like the first car with the addition of a small storage battery for lighting when the plant was shut down.

The third car is typical of all of the recent General Electric designs. This is a steel car 70 ft. long, weighing 50 tons, divided as before with a seating capacity of 45. Heating is accomplished by passing cooling water from the engine through coils situated within the car before passing to the radiator situated on the roof. The engine is an eight cylinder, 125 hp. V-type 550 r. p. m. machine which is started by compressed air. It is direct-connected to an 80 kw. GE T. D. type generator without the additional exciter used on previous cars. Current is supplied by two standard GE railway motors located on the forward truck. The control is effected by throttle, field resistance and series-parallel motors. The lighting of the later and larger cars is supplied by an independent gasoline-electric unit.

The second car of the General Electric Company was sent out to various railroads for demonstration purposes. It covered a great many thousand miles and gave entire satisfaction. Modifications of the third type have been supplied to various railroads as noted in the monograph on the General Electric Company's cars.

The essential differences between the General Electric and Strang gasoline electric cars were in the type of engine used, method of control and large storage battery as auxiliary. The Strang engine was of the six cylinder vertical type and only the series-parallel method of control was used. The Strang car had an auxiliary battery of 300 amp-hour capacity to assist on the peak loads and to operate the car about terminals when the plant was not running. This car is said to have made a mile in fifty-seven seconds on the Pennsylvania Railroad under general service conditions.

In 1904 the North Eastern Railroad of Great Britain tried a

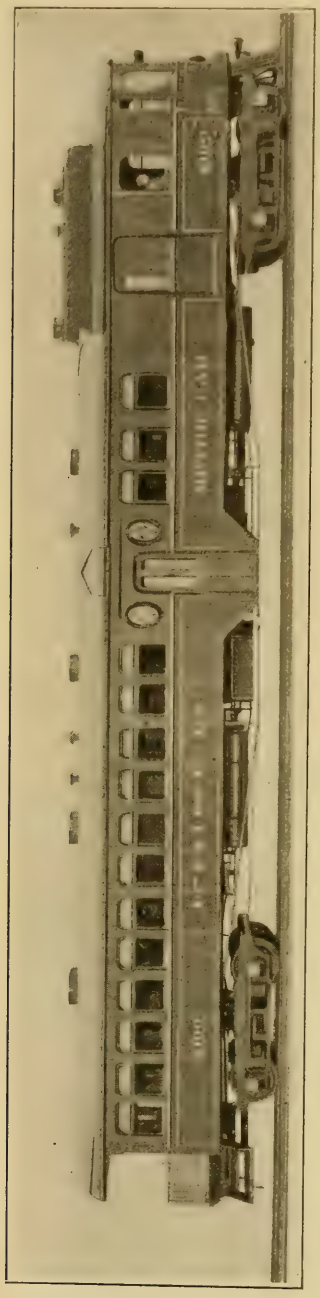


FIG. 10. GAS-ELECTRIC CAR BUILT BY GENERAL ELECTRIC COMPANY, TYPE C. R. E. 70-B-8.

gasoline-electric car (for summer service only). This car weighed 35 tons, had a four cylinder, horizontally opposed 85 hp. engine, direct-connected to a 55 kw. generator with a small exciter and an auxiliary storage battery. The two 50 hp. motors were located on one truck. This outfit was too heavy and cumbersome to meet with success.

Owing to the comparatively recent date at which the gasoline-electric and steam-electric cars have been installed, the data on hand, with the exception of the Arad Csanad Railway, are very meagre and unreliable. The following paragraphs and Table IV, however, summarize all the information which has been obtained on this subject.

In England steam-electric motor cars vary in cost from 2.3 to 6.96 cents per car mile for fuel, making a total cost of approximately 20 cents per car mile. On the Arad Csanad Railway, the fuel cost of the gasoline-electric cars runs from 2.4 to 4 cents per train mile. In the United States the fuel cost for the gasoline-electric cars varies from 5 to 7 cents per car mile, making a total cost varying from 11.3 to 17 cents per car mile.

TABLE IV — COMPLETE OPERATING COSTS OF GASOLINE-ELECTRIC CARS*

American Gas-Electric Cars (Cost in cents per car mile).

KEY	Weight tons	Fuel cost	Oil cost	Platform expense	Staff	Miscellaneous	Maintenance	Total
a.....	35	4.83	0.48	7.71	———	7.07	———	13.72
b.....	48	5.00	1.00	6.00	———	2.00	3.0	17.00
c.....	12	4.0–6.0	0.50	———	———	———	———	13.0–16.0

a First General Electric Car.
b Buffalo-Rochester and Pittsburgh Railroad.
c Third Avenue Railway.
* Complete table of costs in *Electric Railway Journal.* September 23, 1911, 490, Vol. 38.

Arad Csanad Railway (Cents per car mile).

YEAR	Mileage	Staff	Fuel	Lubrication	Miscellaneous	Cleaning, etc.	Repairs	Taxes	Total
1903.....	67,000	2.18	2.58	0.74	1.66	0.10	1.76	4.02	13.04
1904.....	166,000	2.02	2.60	0.38	0.48	0.10	1.54	4.24	11.36
1905.....	192,000	2.18	2.34	0.38	0.74	0.06	1.70	4.30	11.70
1906.....	670,000	2.50	2.86	0.80	0.32	0.10	1.74	4.44	12.76
1907.....	895,000	2.86	3.38	0.64	0.36	0.16	2.32	4.68	14.40
1908.....	920,000	3.26	4.00	0.54	0.78	0.14	2.50	4.90	15.52
1909.....	881,000	3.26	3.26	0.54	0.76	0.20	2.78	5.70	16.50
Steam trains for comparison with above.									
1906.....	244,000	7.40	7.32	0.56	0.88	0.92	4.10	4.40	25.58
1907.....	308,000	7.20	10.66	0.58	0.80	1.16	4.60	4.68	29.68
1908.....	262,000	7.70	9.72	0.68	0.76	2.20	5.12	4.90	30.98
1909.....	307,000	8.08	10.04	0.40	0.76	1.72	5.20	5.70	31.90

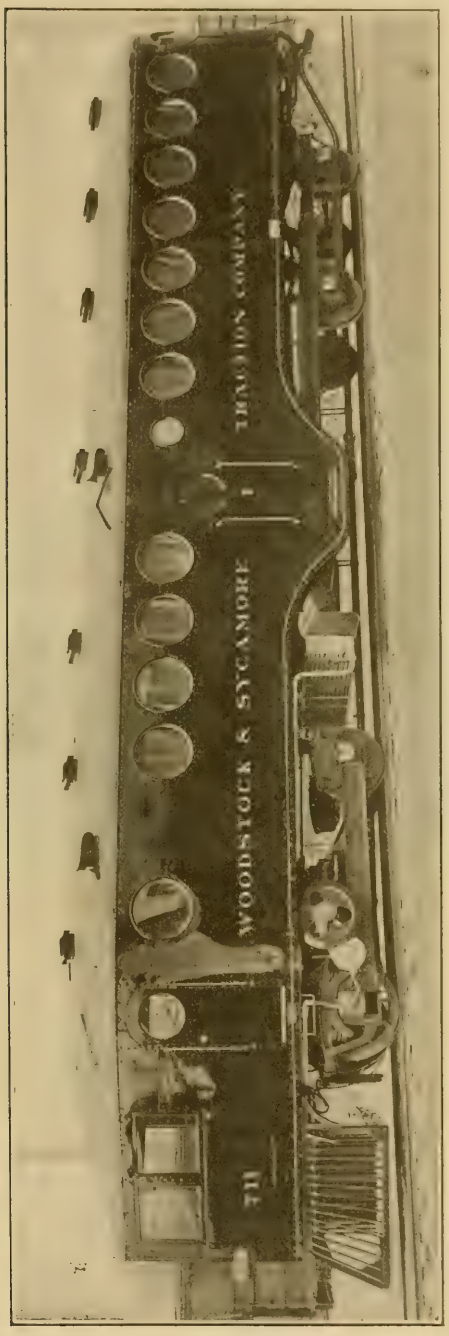


FIG. 11. VIEW OF MCKEEN CAR.

E — Gasoline Cars.

Several different methods are in vogue for suspending the engine transmitting the power to the car axle. The engine may be supported on the underframe of the car or mounted directly upon the truck and the power may be transmitted through bevel gears, chains, or shift cones and belting. Each of these systems will be described in detail later.

A type of gasoline car was used in Wurtemburg, Germany, as early as 1893. Apparently the honor falls to the United States of using the more modern of the gasoline cars, as the Hydro

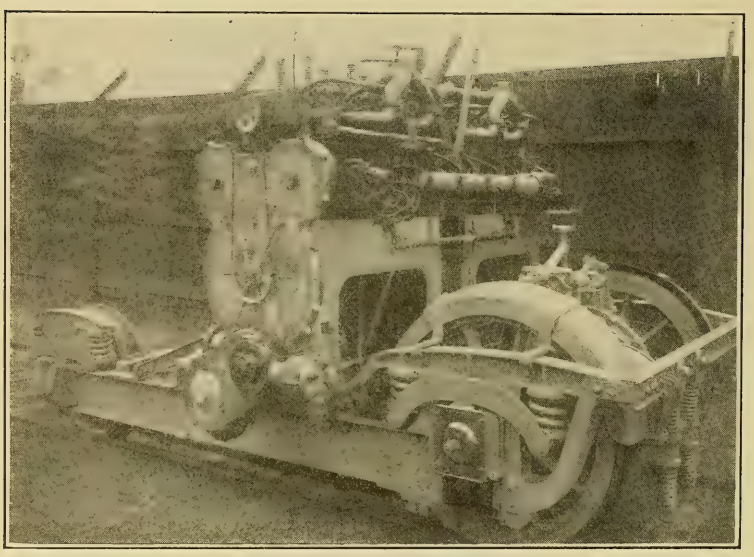


Fig. 12. Side View of McKeen Power Truck.

Carbon Company of Chicago put out a small gasoline car in 1899. This car weighed 21 tons and had a 45 hp., three cylinder, two cycle engine, power being transmitted to the wheels through change cones and clutch. About the year 1901 the Union Pacific Railroad began to develop a straight gasoline car for use on lines with light traffic. This type is now known throughout the world as the McKeen motor car. The original car, which was 31 ft. long, was mounted upon one four wheel truck. On this truck, located crosswise, was a vertical engine connected to the axle by a Morse "silent-chain" and clutch. These cars are at present so well known and are used so extensively that perhaps a brief statement as to its motive power will be sufficient. These cars are now

built of steel to a length of approximately 70 ft., and seat as many as 105 passengers. The equipment includes a compressed air starting device and a 200 hp., six cylinder vertical engine placed crosswise over the center of the truck, driving an auxiliary shaft parallel to and between the axles of the truck. Connection to the axle carrying the driving wheels is made by a 5 in. silent running chain through a friction clutch. This equipment can drive

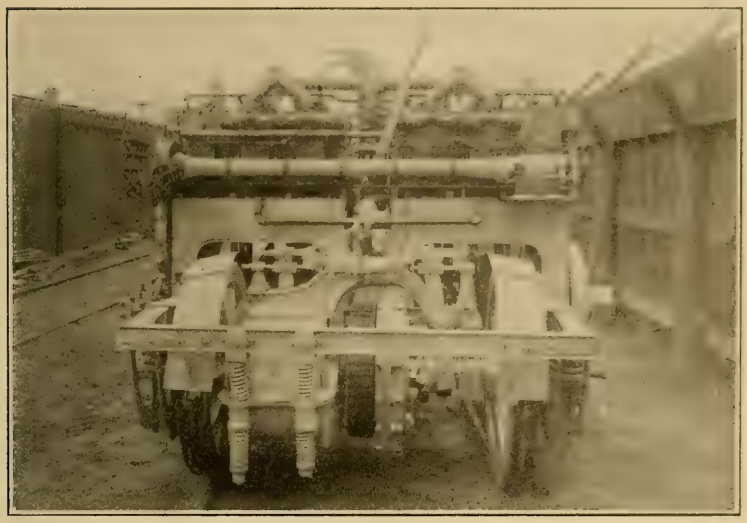


Fig. 13. End View of McKeen Power Truck.

these 34 ton cars at 79 m. p. h. maximum speed on level track. In May, 1912, there were 124 McKeen cars (every car built to date in service in the United States, Mexico and Australia), thus constituting the largest number, in the world, of self-contained motor cars of a given type.

Among the American roads which are using this car are the following:

Union Pacific Railroad,
Central Pacific Railroad,
Santiago, Cuyamaca & Eastern Railroad,
Illinois Central Railroad,
Galveston, Houston & Santiago Railroad,
Erie Railroad,
Chicago & Northwestern Railroad,
Los Angeles & San Diego Beach Railway,
Silver Peak (Nev.) Railroad.

Following the advent of the McKeen car, several English firms also put out gasoline cars. Thus, in 1905, Dick, Kerr & Company supplied an experimental car to the Great Northern Railroad for trial on the Hatfield & Hertfield Branch. The weight of this car was approximately 16 tons. It was driven by two 36 hp. Daimler engines supported on the truck frame which drove a single longitudinal shaft connected to axles through beveled gearing. The Daimler system is also used on the Arad Csanad and Swiss Federal Railroads. The Wurtemburg State Railways of Germany have several cars of the gasoline driven type.

So far as American practice is concerned, the McKeen cars are notable for their great length. However, somewhat smaller cars have also been built for use in the United States. Several types of gasoline motor cars have been brought out in recent years, notably by the Stover Car Company in 1908 the Fairbanks-Morse Company in 1909 and the Rock Island Railroad in 1909. The Fairbanks-Morse car, as used on the Smyrna Branch of the Pennsylvania Railroad, and the Alaska Northern Railway, is a 15 ton, 34 ft. single-truck car seating 35 passengers. The motive power consists of a four cylinder, 50 hp. engine which transmits power to the axle by means of gears. The 25 passenger car in use on the Rock Island Railroad can be driven at 30 m. p. h. by a 60 hp. six cylinder gasoline engine supported on the under frame of the car and is chain-driven to the axle.

The operating costs for the smaller gasoline motor cars range from 8.3 to 18 cents per car mile. The following figures, Table V, give the operating cost per car mile for the Fairbanks-Morse and the Rock Island car of approximately the same horse-power but of widely different seating capacity:

TABLE V — OPERATING COSTS OF TWO GASOLINE CARS.

ROAD	Seats	Miles run	Passengers	Crew	Materials	Labor	Gasoline	Oil	Supply	Total	Cost per car mile (cents)
Fairbanks-Morse.....	60	2,867	4,600	$113 65	$9 09	$21 80	*558 $58 60	$25 84	$8 33	$237 31	8.3
Rock Island..	25	3,262	3,493	135 00	2 10	11 30	*381 40 00	10 75	.....	199 15	6.1

* Gallons.

The foregoing table should obviously include superintendence, maintenance, interest and depreciation which would bring the total cost to 16 cents per revenue car mile for the Rock Island system. For the Fairbanks-Morse system, no data is at hand for obtaining the total cost.

Conclusions.

It is hardly within the scope of this paper to discuss at length the relative merits of the various types of modern motor cars. However, it may be profitable to point out those features of each type which make it best adapted for a given field of service.

As a class, the steam, steam-electric, gasoline-electric and gasoline motor cars possess the fundamental quality upon which the development of the self-propelled car depends, namely, low financial investment and reasonable operating cost. Such cars seem best suited for the branch lines of steam railroads where infrequent service, light traffic and numerous stops are required.

The steam-driven car has not come into prominence because it offers little advantage over the locomotive and trailers, furthermore, the smoke and dirt still remain as objectionable features. The steam-electric combination would offer the advantage of variable speed control, but, of course, would also fail to eliminate the objections just noted.

The compressed-air car is essentially heavy and requires a great deal of space on account of air storage. The efficiency of compression and expansion in the motors is low while the air pressure is high and difficult to maintain against leakage. The radius of action is very limited unless the user goes to the expense of installing compressor stations at frequent intervals. In short, the compressed-air car is rarely used except for very special conditions, such as obtain in gaseous mines, chemical factories, etc., where sparks and dirt would be dangerous and where in any event the radius of action is small. Fireless locomotives with tanks of water charged with steam are sometimes used instead of compressed-air even in these special fields.

The internal combustion engine driving either an independent car or a locomotive with or without electric transformation gives promise of being the best adapted to heavy service and long runs. The improvements made with this type of equipment during the past few years and the commercial experience which has been attained therewith is so encouraging that even further betterments are probable.

Both the gasoline and gasoline-electric car have a large radius of action and are, therefore, suitable for the longer hauls, such as are found on the feeders of main line steam railroads where the traffic is not heavy enough to justify the operation of more than a very few trains a day. Similarly, the self-propelled car of this type is suitable for new interurban lines pending the development of enough traffic to justify electrification. It may reasonably be expected that a considerable portion of the service now looked upon as legitimately belonging to the steam locomotive and electric trolley will ultimately be operated by internal combustion

propelled units with better economical results. It may be added, however, that neither of these types is likely to have much application in strictly city service, principally on account of the weight per passenger, the maintenance, and the mechanical difficulty of negotiating the sharp curves found on city tracks.

In comparing the straight gasoline and gasoline-electric cars for long haul service, the advocates of the latter urge the advantage of a very flexible electrical control which permits the gasoline engine to be driven at constant speed and which eliminates the direct mechanical drive to the wheels which has been the greatest source of trouble and expense on the gasoline car. The disadvantages of the gasoline-electric car, however, are the high first cost, due to the additional electrical equipment, and the lower efficiency due to the conversion of mechanical energy to electrical energy. The perfection of a suitable drive for the gasoline car should, therefore, make it preferable to the gasoline-electric car in those situations where the stops are not numerous enough to make the flexibility of control and the possibility of double-end operation of essential value.

The storage battery car appears best for the following situations: *First,* upon unimportant lines in cities where the overhead trolley is forbidden, and the cost of a conduit system would be prohibitive. *Second,* where it would be feasible to charge a certain number of cars during lowland periods for use during rush hour service. *Third,* for use on the extensions of suburban lines until such time as the increased traffic justifies the installation of a sub-station and overhead trolley system. Even in the cases cited, however, the storage battery car should be considered with great caution if the prevailing grades are excessive and if the cost for electrical energy is more than, say, 3 cents per kw-hour.

In conclusion, the following tables are submitted to show comparative operating costs of various types of cars abroad. It was taken chiefly from the *"Engineering News"* for April 20, 1893:

TABLE VI — OPERATING COST FOR FOREIGN SYSTEMS.

ROAD	Length in miles	Motive power	Cost of equipment per mile	Operating cost per car mile (cents)
Geneva City	8.68	Horse	$60,800	18.4
Zurich	5.58	Horse	39,700	11.6
Geneva Suburban	40.30	Steam locomotive	32,000	13.2
Mulhouse City	18.00	Steam locomotive	22,400	17.8
Montreux Suburban	6.82	Hydro-electric	20,800	10.4
Florence Suburban	4.96	Steam-electric	32,000	20.0
Tours Suburban	6.20	Steam cars	19,200	17.2
Nantes Suburban, Paris	7.44	Steam and compressed air	46,100	25.6
Berne City	1.86	Hydro-compressed air	48,950	17.2
Arad Csanad	290.00	Gasoline-electric	.....	26.8

Table VII gives the cost of operation of European Railway motor cars taken from the Transactions of the *"American Society of Mechanical Engineers,"* June, 1907. This table includes operating cost, fuel, oil, repairs and drivers' wages:

TABLE VII — COST OF OPERATING EUROPEAN RAILWAY MOTOR CARS.

RAILWAY	Type	Horse power	Average weight, train tons	Operating cost, train mile	Cost fuel	Labor, wages of driver	Remarks	Average running speed M. P. H.
Great-Western.....	Steam.....	250	55, inc. trailer.....	$0.13	$3.00 ton.....	$1.75	20 lb. per train mile.	35
North-Eastern.....	Petrol-electric...	85	35.....	0.15-0.16*	0.30 gallon....	.....	3.5 miles per gallon, claimed. 9 cents per mile fuel.	30
Paris-Orleans.....	Purret-steam....	260	50, inc. trailer.....	0.08	Coke, $6.00 ton.	1.40	21 lb. per mile	35
Arad Csanad.....	Gasoline-electric.	70	†20.....	0.073	$0.10 gallon....	About 1.20	2.11 lb. gas. per mile, 2.7 miles per gal.	35
Arad Csanad.....	Ganz-steam.....	35	40, inc. 2 trailers..	0.075	Coke, $5.00 ton.	About 1.20	9.6 lb. per mile	25
Arad Csanad.....	Gasoline-electric.	35	†40, inc. 2 trailers..	0.057	$0.10 gallon....	About 1.20	1.61 lb. per mile, 3.75 miles per gallon.	20
Austrian State.....	Kourarets-steam	100	50, inc. 2 trailers..	0.05	Coal, $3.25 ton..	About 1.20	15 lb. per mile.....	25

* Probably. † Approximate.

Table VIII, giving the cost of gasoline-motor cars for railway service, is taken from the paper presented by W. R. McKeen, Jr., before the New York Railroad Club, April 19, 1907. The figures cover the Ganz motor cars, McKeen gasoline cars, electric cars and steam locomotives. It will be observed that the expense of fuel, cleaning, repairs, etc., runs very uniformly, but the cost of operation per mile is so dependent upon the number of miles run a day that comparisons are very unsatisfactory. In some places the cars run for 10 cents and 11 cents per mile, whereas in other localities the cost is 16 to 18 cents per mile. In one case where a 100 hp. motor car and trailer replaced a steam locomotive train, the limited mileage brought the cost up to 20 cents per mile:

TABLE VIII — COMPARATIVE COST OF OPERATION IN CENTS PER TRAIN MILE.

ITEM	Ganz motor cars			Gasoline cars			Electric cars			Steam locomotives		
Car miles per day	180	540	960	180	540	960	180	540	960	180	540	960
Repairs to motor equipment	2.0	2.0	2.0	2.2	2.2	2.2	0.7	0.7	0.70	.....	.....	.....
Repairs to cars	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.30	0.3	0.3	0.3
Repairs to locomotive	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.0	7.0	7.0
Repairs to overhead	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Construction sub-station	.....	.....	.....	.....	.....	.....	7.0	2.4	1.40	.....	.....	.....
Wages engineer and assistant	.....	.....	.....	3.2	3.2	3.0	.....	.....	.....	.....	.....	.....
Wages engineer and firemen	3.2	3.2	3.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wages motormen	.....	.....	.....	.....	.....	.....	1.7	1.7	1.25	.....	.....	.....
Wages conductors	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.25	1.6	1.6	1.6
Wages sub-station attendant	.....	.....	.....	.....	.....	.....	1.4	0.5	0.40	.....	.....	.....
Cleaning, light, repairs, inspection	1.5	1.5	1.5	2.0	2.0	2.0	‡.....	‡.....	‡.....	3.8	3.8	3.8
Fuel	1.8	1.8	1.8	*15.0	15.0	15.0	.....	.....	.....	10.0	10.0	10.0
Fuel and water station, operation, repairs, etc	0.3	0.3	0.3	.....	.....	.....	.....	.....	.....	0.8	0.8	0.8
Cost of power†	.....	.....	.....	.....	.....	.....	6.8	3.7	3.20	.....	.....	.....
Oil, waste and other supplies	0.4	0.4	0.4	0.6	0.6	0.6	0.1	0.1	0.10	0.8	0.8	0.8
Interest, insurance and depreciation	5.3	2.7	2.5	5.5	2.7	2.5	17.2	6.0	4.70	4.9	2.5	2.1
Total	16.4	13.8	13.4	30.4	27.6	27.2	36.6	17.0	13.30	32.4	30.0	29.0

* Based on consumption ¾ gal. per mile, 20 cents per gal.
† Includes fuel, labor, repairs, supplies.
‡ Included in item of "Repairs."

Table IX was also taken from the same paper which contained Table VIII.

TABLE IX — COMPARATIVE INVESTMENT.

ITEM	Ganz motor cars, steam			Gasoline cars			Electric cars			Steam locomotive		
Car miles per day	180	540	960	180	540	960	180	540	960	180	540	960
Number of motor cars or steam locomotives	2	3	5	2	3	5	2	3	5	2	3	5
Motor cars	$35,000	$52,500	$87,500	$35,000	$52,500	$87,500	$16,000	$24,000	$40,000	.....	.....	.....
Steam locomotives	.....	.....	.....	.....	.....	.....	.....	.....	.....	$20,000	$30,000	$50,000
Number of steam passenger cars	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	3	5
Cars	.....	.....	.....	.....	.....	.....	.....	.....	.....	12,000	18,000	24,000
Overhead construction and bonding	.....	.....	.....	.....	.....	.....	18,250	68,250	68,250	.....	.....	.....
Sub-station	.....	.....	.....	.....	.....	.....	3,500	3,500	7,000	.....	.....	.....
Gasoline storage	.....	.....	.....	1,000	1,000	1,000	.....	.....	.....	.....	.....	.....
Power station	.....	.....	.....	.....	.....	.....	25,000	25,000	25,000	.....	.....	.....
Total	$35,000	$52,500	$87,500	$36,000	$53,500	$88,500	$112,750	$120,750	$165,250	$32,000	$48,000	$74,000

The conditions assumed for Tables VII and IX were as follows:

Service:

Single track line 30 miles long,
Stops every 5 miles,
Tangent level track,
Cars seating 50,
Maximum speed 35 m. p. h.

First costs:

Electric cars,	$8,000.	Power station, $110 per kw.	
Ganz cars,	17,500.	Sub-station, $35 per kw.	
Gasoline cars,	17,500.	Bonding, $275 per mile.	
Locomotives,	10,000.	Overhead construction, per mile.	$2,000
Cars,	6,000.		

Fuel consumption:

Steam locomotive (150 ton train), 80 lb. per mile,
Ganz car, 12 lb. per mile,
Gasoline car, 0.75 gal. per mile and 0.5 gal. per mile,
Electric car, 60 watt-hours per ton mile at trolley.

Labor (wages per day):

Engineer,	$3.50	Conductor,	$3.00
Fireman,	2.25	Motorman,	3.00
Assistant,	2.25	Substation attendant,	2.50

Miscellaneous:

Efficiency of transmission bus bars to car motors, 75 per cent; repairs to overhead construction, $1.50 per mile per annum; repairs to power, etc., and sub-station machine 4 per cent of capital charge.

Fixed charges (interest, insurance, depreciation) at 10 per cent. Works cost per kw-hour at station: 180 car miles a day, 2.1 cents; 540 car miles a day, 1.2 cents, and 960 car miles a day, 1.0 cent.

EXPERIMENTS WITH SELF-PROPELLED CARS BY THE THIRD AVENUE RAILWAY

Early in April, 1909, the Third Avenue Railway, New York, made arrangements for testing one storage battery car and one gasoline-electric car for the purpose of finding an efficient substitute for certain crosstown horse car lines which could not be electrified according to the conduit system demanded for Manhattan Borough, New York, except at prohibitive cost.

Gasoline-Electric Car

The gasoline-electric car was received on October 25, 1909, and was immediately placed in operation on the 125th Street crosstown line, where it was sandwiched between the regular conduit

system cars on this busy route. The 125th Street line is 2.1 miles long and from 15 to 21 stops are made in each direction. The round trip running time is 30 to 33 minutes and the headway 2.5 minutes with no allowance for lay-overs. The car was operated for 15 hours every day. It was considered desirable to place the gasoline-electric unit in such severe service in order to discover any weakness which might occur much sooner than if the runs were made on the lower traffic horse car routes. It was specified that the car should be capable of running on a 5 per cent. grade, and that when on level track, it should maintain a schedule speed of 8 m. p. h. at ten stops per mile. All conditions in regard to the operating features were easily made and even exceeded, but as the sequel will show, the cost of operation was too great.

DESCRIPTION OF EQUIPMENT

The gasoline-electric car was of the single-truck type. The roof which was of the single arch type, carried eight ventilators and the water cooling radiators which were mounted on the roof near the center of the car. The exhaust pipes were brought up to the roof at one end of the car. Sufficient gasoline for 150 miles operation was carried in tanks under the longitudinal seats.

The body was 28 ft. long over all, 19 ft. long over the body end frames, 8 ft. wide and 12 ft. high from the top of the rail to the roof. It seated 26 to 28 passengers, and as the total weight of body, truck and apparatus was 24,000 lb. the respective weight per passenger was 923 lb. and 857 lb. These weights compared very favorably with the average electric double-truck car, but on account of the strains which had to be cared for, this car was several hundred pounds heavier per passenger than the same company's storage battery cars. All of the motive apparatus, except the usual style of electric controller and brake handle were carried on the truck. This truck was provided with coil springs and also with half eliptic springs at the end. The gas engine was of the four cylinder, four cycle type direct-connected to the generator and exciter. Two railway motors were mounted on the axles.

The controllers on each platform connected the motors progressively in series and in parallel, and regulated the voltage supplied by the generator as required by the speed of the car. Thus all mechanical connections between the gas engine and the driving axles were eliminated. The gas engine had an automatic centrifugal throttle governor and ran at constant speed. The operator had no auxiliary devices for controlling either the gas engine or the car. The engine was started by a crank direct from the magneto. The exciter previously named supplied the current for the main generator field and for lighting.

The water cooling radiators on the roof were connected to the water jackets of the cylinders by pipes enclosed within the center posts of the car. The circulation was designed on the semi-syphon principle. In cold weather the cooling water was arranged to pass through heater pipes under the seats. The arrangement for taking care of the exhaust through the roof connection kept the odor of gasoline from entering the car. It was also found that mounting the machinery on the truck avoided serious vibration of the car body.

RESULTS WITH GASOLINE-ELECTRIC CARS

The gasoline-electric car was in operation from November, 1909, until the middle of September, 1910. It was then removed from the line and its motive apparatus applied to a snow sweeper.

From October 29, 1909, to May 9, 1910, inclusive, a detailed daily record was kept of every important operating feature. During this period of 170 days a total of 11,624 miles were run. This was equivalent to practically 25,000 miles per annum, but the estimated performance of 30,000 miles could have been reached without trouble, if demanded by operating conditions. On the maximum mileage basis the expense per car mile was estimated at 3.1 cents for the fixed charges and 2 cents for the maintenance. Depreciation was figured at 8 per cent.

The gasoline consumption averaged about 0.55 gallons per revenue mile, although the car weight was about 12 tons. It was found possible to use grades costing only 11.35 cents per gallon. The cost of gasoline per revenue mile varied from 4 to 6 cents. Cylinder lubrication added about 0.5 cents per revenue mile, but motor lubrication cost was negligible. These charges plus the platform and miscellaneous expenses made the total costs per revenue mile range from 13 to 16 cents. The number of non-revenue miles did not increase these costs materially, as the car was stored within 0.25 mile of its route.

The total gross earnings per revenue mile varied from 28.5 to 35.4 cents. Roughly speaking, these gross earnings were about twice the operating expenses, excluding 3.1 cents for fixed charges, 2 cents for car maintenance and 0.25 cents for track maintenance. The earning power of this car proved to be practically as high as those of the regular double-track cars on this route. However, the earnings over the horse car route would have been so much less that the gasoline-electric car would have been operated at a heavy loss. The only interruption in service was due to the breakage of a defective shaft, but otherwise the car operated as smoothly as could be desired.

Tests made jointly by the General Electric Company and the Third Avenue Railway, showed that the car exceeded its guarantees. In one instance it climbed an 8 per cent. grade, although 5 per

cent. was the assumed limit. In one test where the car ran round trips of 4 miles each and made eight five-second stops per mile, the gasoline consumption was 0.5 gallons per mile, compared with the guarantee of 0.6 gallons. The schedule speed was 8.45 m. p. h., an excess of 0.45 m. p. h. over the guaranteed speed. The average energy consumption was 104.5 watt-hours per ton mile, and an acceleration of 1.05 m. p. h. p. s. was obtained when going down and 0.83 m. p. h. p. s. when going up a grade of 0.72 per cent. The only test which did not show better than the guarantee was in temperature where a heating limit of 65 deg. C. was specified. As high as 77 deg. C. was noted and was measured at the commutator of the motor which was nearer the engine muffler, when the temperature of the outside air was 12 deg. C. It should be stated, however, that this exceptional rise was due to the fact that the car was making 9 to 13 stops per mile instead of the 8 stops per mile upon which the 65 deg. C. specification was based.

Storage Battery Cars

The first storage battery car which was put in service in March, 1910, consisted of a former horse car body and with its truck made up in the company's shops, weighed 7,200 lb. The construction of the car body was changed in few respects except that the bulkheads were removed and vestibule doors and folding steps added to permit prepayment operation. The body was 17 ft. 10 in. over the corner posts and had 4 ft. platforms. It seated 26 passengers and, including equipment, weighed six tons, or only 461 lb. per passenger. Because of the light weight of the car and the use of roller bearings in the journal boxes, and ball bearings in the armature journals, not more than two 5 hp. automobile type motors were required to operate at the schedule speed of 7 to 8 m. p. h., making 8 stops per mile. The "silent-chain" drive was used. The lead storage battery consisted of 44 cells, each cell containing 29 Gould high-capacity plates. At 84 volts, the battery had a rating of 420 ampere-hours. The batteries were placed under the longitudinal car seats, the gases being carried off by the natural ventilation, which was afforded when the movement of the car sent air through a pipe on each side of the car. As this air passed over the batteries it drove off the odors and exhausted them under the step at the back of the car.

The operation of the first car was so satisfactory that during the early part of 1910 the company built in its own shops 25 new car bodies and rebuilt five horse car bodies. The principal data on these cars were as follows: Length of car over bumpers, 26 ft. 1.5 in.; over body, 18 ft.; width of car, 7 ft. 6 in.; height from rail to roof, 10 ft. 8 in.; seating capacity, 26; trucks of structural

shapes mounted on 30 in. wheels with ball bearing journals; two 30 amp. 125 volt motors with "silent-chain" drive from motors to axles; battery equipment of Gould 58 cells. The total weight of the cars, including all equipment, was slightly over 7 tons. The maximum free running speed was approximately 15 m. p. h. and the schedule speed with eight stops per mile, 7 m. p. h.

Recent records taken from the ampere-hour meters installed on these cars selected at random show a variation in current consumption from a minimum of 4.92 ampere-hours per car mile to a maximum of 6.09 ampere-hours per car mile, with an average of 5.53. Owing to the more favorable operating conditions, the energy consumption on the 110th Street line is about 10 per cent. less. The individual motorman's record also shows a watt-hour variation, namely, from 4.42 ampere-hours minimum to 6.72 maximum. This indicates that the skill of the motorman is an important factor in determining the energy consumption of the car, and, therefore, in the cost of operation and the total mileage available on a single charge. The energy consumption measured on the d. c. circuit, therefore, includes all the conversion in battery losses and averages about 1 kw-hour per car mile. In general, the energy input on the motors on the storage battery cars varies from 60 to 85 watt-hours per ton mile according to conditions.

The following Table X compares electrically the original lead battery with the single Edison battery equipment which was in use on the Twenty-eighth and Twenty-ninth Street crosstown line from about January, 1910, until December 18, 1910, when this line was taken over by the Third Avenue Railway under an operating agreement:

TABLE X — COMPARISON OF TWO TYPES OF BATTERY CARS IN NEW YORK.

BATTERY CAR	Edison	Lead
Average daily run in miles	51.400	61.900
Kw-hours per car mile, at motors	0.603	0.507
Kw-hours per car mile, purchased	1.910	0.973
Kw-hours per car mile, battery input	1.480	0.853
Ampere-hours per car mile, of charge	8.700	5.520
Ampere-hours per car mile, of discharge	5.000	4.530
Ampere-hour efficiency of battery, per cent	57.500	82.000
Voltage efficiency of battery, per cent	71.000	72.700
Watt-hour efficiency of battery, per cent	40.800	59.600

A remarkable feature in connection with the battery contract was that while the batteries were purchased outright by the railroad, the battery companies agreed to maintain them for five years. This maintenance consists of renewal, cleaning, washing,

supplying electrolyte and making all necessary repairs to maintain the batteries at 75 per cent. of their rated output.

These thirty cars were put in service between September and December, 1910, and during 1911 fifty similar cars with Hycap-Exide were put in service, the only mechanical changes being that roller bearings were used in the axle bearings and the drive was changed to direct gearing as the higher maintenance cost of the chains outweighed any little superiority which chains might have to gearing in the matter of efficiency. It was found that after some wear of the sprockets, the chain did not mesh for proper riding and the individual links wore very rapidly. On the other hand, a car that was equipped with gearing ran for over 6,000 miles without any loss in efficiency. A third change was to construct the truck in such a manner that if desirable the batteries could be carried upon it instead of under the seats.

The performance of the battery cars in general has been most satisfactory for the service for which they were intended, and they have proven entirely reliable both in summer and winter. The record of a single day's run on the Twenty-eighth and Twenty-ninth Street crosstown line taken at random showed 11 cars in operation, of which two made 86 miles each while the average performance was 66.5 miles. A similar record from the Avenue B line showed a maximum of 87 miles and an average of 61.5 miles. The best performance on one charge for cars making their regular schedule has been 125 miles. This is much in excess of what is required in average service, which is approximately 70 miles per day. The reserve capacity, however, is necessary to counteract the severe conditions during the winter months.

For the months of October, November and December, 1911, the cost of operation for battery cars on the Avenue B line was 14.14 cents per car mile. This cost included platform expenses, repairs to cars, trucks and electrical equipment, battery maintenance and charging, including power, expenses of car cleaners, shifters, elevator men, etc. It is considered probable that the average expense for operation per car mile for several years would be somewhat greater than the figure given, in view of the fact that the cars are practically new.

It will be seen from the figures given that the difference in operating costs of the two types of self-propelled cars is not very great. The storage battery cars were adopted, however, because they were much lower in first cost and offered much simpler maintenance conditions than the gasoline-electric equipment. For instance, the cost of rebuilt cars, including painting and installation of equipment, was about $375 each. It would not have been practicable, of course, to adapt the horse car bodies to gasoline-electric service.

The following is a summary of the Third Avenue Railway storage battery passenger car equipment, giving general dimensions, apparatus, weights, operating features and rating costs:

TABLE XI — DATA ON THE PREPAYMENT TYPE OF STORAGE BATTERY CARS OPERATED BY THE THIRD AVENUE RAILWAY, NEW YORK.

GENERAL DIMENSIONS:

Length over all	26 ft. 1 in.
Length over corner posts	18 ft. 1 in.
Width over all	7 ft. 8 in.
Height over all	10 ft. 8 in.
Height over step	15 in.
Height over platform	28 in.
Height platform to floor	6 in.
Wheel bore	7 ft. 4 in.

EQUIPMENT:

Brakes:	Peacock hand brake, former type 45 lb. each; later type 25 lb. each.
Heaters:	Special coal burning hot air heaters.
Lamps:	28 volt series burning Tungsten lamps.
Registers:	International registers.
Meters:	Sangamo ampere-hour meters.
Bearings:	Railway roller bearings, Hess-Bright ball bearings.
Fenders:	H-B life guards.
Controllers:	Two GE K-45A series parallel controllers.
Motors:	Two GE 30 amp. 85 volt automobile motors, adapted to railway work.
Gear reduction:	14-78.
Batteries:	58 cells with 29 medium thin high-capacity pasted plates.
Battery capacity:	420 ampere hours.

WEIGHT IN POUNDS:

Car body	4,103
Truck	985
Wheels (4)	1,000
Axles (2)	460
Heater equipment complete	300
Controllers (2)	240
Motors complete with gears, pinions and gear cases	1,294
Fenders (2)	346
Batteries	4,876
Approximate complete weight	14,000

OPERATING FEATURES:

Schedule speed in m. p. h.	6.5
Stops per mile	10–11
Miles a day	70–100
Length of time for charge in hours	6.5–9
Miles per battery failure, averaged from January to June, 1912	221,900
Miles per electrical failure, same period	49,300
Car days per heater failure	146
Coal per car per diem in pounds	13.7
Miles per car failure for all causes	3,440

OPERATING COSTS PER 1,000 MILES OF FIFTY-SIX CARS, JANUARY TO JUNE, 1912.

Lubrication	$0.14
Lamps	1.20
Painting	1.87
Car body repairs, except painting	6.00
Truck repairs	0.93
Total maintenance exclusive of batteries	$10.14

Three routes are now operated with storage battery cars by this company, namely, St. Nicholas Avenue and 110th Street crosstown line, round trip, 4.97 miles; 28th and 29th Streets crosstown lines, round trip, 4.63 miles, and Dry Dock, East Broadway & Battery line round trip, 7.04 miles. All of these lines were designed for horse car operation. The rails are light and have been in use for many years and curves of short radius are common. Few repairs were made to track and roadbed to fit them for storage battery service. The hardest operating condition is on the Dry Dock line, which traverses the crowded East side of Manhattan Island. On this line the car stops, for all reasons, are on an average of from 10 to 14 per mile.

STORAGE BATTERY SWEEPERS, ETC.

The company has also constructed four storage battery snow sweepers, in which the brooms are driven by a separate motor instead of jointly by one motor as is customary. These motors are mounted under the floor of the sweeper and connected with the brooms by roller chains. The broom motors are of the same size and type as used on the battery cars. The axle driven equipment of the sweeper consists of two 110 volt, 60 ampere motors geared directly to the axles. A novel feature is the connection of the two axles by means of roller chains and sprockets

so that when the motors are in series position, there can be no slipping of wheels, thus making the sweeper very effective for slow running through crowded traffic. The motive power is obtained from two storage battery sets of 58 cells which are carried on the floor of the sweepers. These batteries are of the same size and type as those used in the passenger cars. The sweepers gave excellent service during the past winter, showing themselves easily capable of doing all the work that was required of them.

In May, 1911, the company permitted the Commercial Truck Company of Philadelphia to install one of its trucks under a storage battery car body. A feature of this truck is the four-wheel drive, each of the four motors driving a single wheel through reduction gearing. The car body was later sold to the truck builder.

COMPARISION OF STORAGE BATTERY AND OVERHEAD TROLLEY FOR A TYPICAL INSTALLATION

The following paragraphs are an abstract of a report which was made by a consulting engineer to his client after a thorough examination of several important storage battery installations. This report was made to determine whether storage batteries should be preferred for a proposed line 9.5 miles long. The comparison is on the basis of first costs, operating costs and general maintenance.

Storage battery cars are being operated successfully by the Third Avenue Railway, New York City, which are using 82 lead battery type cars on its regular lines. The following companies have cars with Edison batteries in successful operation:

Name of Company	No. of cars	Car miles run per day	Length of line in miles
Suffolk Traction Co., Patchogue, N. Y.	2	110	2.00
New Castle & Delaware City, New Castle, Del.	*1	184	9.60
Carolina Traction Co., Rock Hill, S. C.	2	110	2.71
Charlotte Rapid Transit Co., Charlotte, N. C.	2	112	3.60
Salisbury & Spencer Ry. Co., Concord, N. C.	1	99	1.50

* This is a 4-motor interurban car.

All plants were found to be satisfied with results obtained.

The cost of operation of any storage battery car will be more than the cost of operation of a direct trolley car of the same weight. By actual test on the Third Avenue line and other roads, the watt-hour efficiency of storage batteries varied from 40 to 60

per cent. while the efficiency of the No. 0000 trolley is about 90 per cent.

The cost of current for a car equipped with Edison batteries will be 30 per cent. more than with lead batteries or direct trolley. This was the regular practice of the plants visited, as they put back 30 per cent. more current than they took out on each booster charge, due to the lower efficiency of Edison batteries. Take for example two cars of the same weight running on the same track under the same conditions; the Edison battery would require 130 kw., while the lead battery would require 100 kw. to operate a seven ton car 100 miles. The best results are obtained by frequent boosting of battery, and this method of charging also reduces the number of cells necessary. No car was found that would run 150 miles without being given a booster charge.

The cost of maintaining the lead batteries will be about eight times that of the Edison per car mile operated. In electric trucks, where we found some good records of maintenance cost kept by the Commonwealth Edison Company, Chicago, for the last two years, the Edison battery operated trucks cost 0.3 cents and the lead battery operated trucks cost 4.12 cents per truck mile. Taking the life of the Edison battery at seven years, its maintenance cost would be about 0.5 cents per car mile. The maker is, at present, guaranteeing this battery for four years.

A comparison of trolley cars and storage battery cars for a given situation follows in Table XII.

TABLE XII — COMPARATIVE COSTS OF TROLLEY AND BATTERY SYSTEMS.

GENERAL:	
Length of road	9.5 miles
Gauge	3 ft. 3 in.
Average grade	0.34 per cent.
SERVICE PROPOSED:	
Hours in service	17
Headway	15 to 20 min.
Stops per mile	8
Schedule speed desired on average	7.22 m. p. h.
Actual speed necessary on average	13.44 m. p. h.
Number of cars regular service	9
Number of cars extra service each day	6
Total car miles per diem	1,227
Total car hours per diem	158
Total car miles per annum	350,000

TABLE XII (*Continued.*)

WEIGHT IN POUNDS:	Storage Battery	Trolley
Car body	4,500	5,000
Motor and control	2,000	5,000
Trucks	4,000	4,500
Thirty-five passengers	4,375	4,375
Battery	2,400	....
Totals	17,275	18,875

CONSTRUCTION COST:	Storage battery	Tro ley
Twenty cars	$90,000	$60,000
Ten miles No. 0000 double trolley	.....	23,900
Station cost at $125 per kw	25,000	43,750
Totals	$115,000	$127,650
Saving in favor of battery car		$12,650 00
Interest on this amount at 5 per cent. per annum		632 50

OPERATING COST:	Car mile	Per year
Regular Trolley Line.		
Maintenance of overhead trolley	$0.003	$1,350
Current estimated 1 kw. per car mile at 1.25 cents	0.0125	5,625
Totals	$0.0155	$6,975
Edison Storage Battery.		
Maintenance of battery, taking life at seven years	$0.005	$2,250
Current estimated 1.43 kw. per car mile at 1.25 cents	0.0178	8,010
Totals	$0.0228	$10,260
Lead Type Storage Battery.		
Maintenance of battery	$0.0325	$14,625
Current estimated 1 kw. per car mile at 1.25 cents	0.0125	5,625
Totals	$0.0450	$20,250

Comparing the Edison battery operation with the regular trolley, there is a saving of $3,285 per annum in favor of regular trolley.

Taking from this the yearly interest saved by the installation of storage battery system $632.50, there is a net saving of $2,652.50 in favor of the regular trolley.

The foregoing estimate is supplemented by Table XIII which follows hereinafter. In this, the cost per car is $6,000 instead of $4,500, but the energy estimated per storage battery car is only 1.19 kw-hours per car mile instead of 1.43 kw-hours per car mile.

TABLE XIII — COMPARATIVE COSTS OF TROLLEY AND BATTERY SYSTEMS.

CONSTRUCTION COST:	Storage battery	Trolley
Twenty cars	$120,000	$60,000
Ten miles No. 0000 double trolley	.....	23,900
Station cost at $125 per kw	25,000	43,750
Totals	$145,000	$127,650
Saving in favor of trolley car		$17,350
Interest on this amount at 5 per cent. per annum		867

COST OF OPERATION:		
Regular Trolley Line.	Car mile	Per year
Maintenance of overhead trolley	$0.003	$1,350
Current estimated 1 kw. per car mile at 1.25 cents	0.0125	5,625
Totals	$0.0155	$6,975
Edison Storage Battery.		
Maintenance of battery, taking life at seven years	$0.005	$2,250
Current estimated 1.19 kw. per car mile at 1.25 cents	0.0148	6,660
Totals	$0.0198	$8,910
Saving in favor of trolley, per year		$1,935 00
Interest on investment saved		867 50
Total savings		$2,802 50

INITIAL AND MAINTENANCE COSTS OF A STORAGE BATTERY LINE

In response to an invitation from the Subcommittee, the Electric Storage Battery Company, Philadelphia, Pa., kindly submitted the following outline to indicate what it would recommend for, and

the results to be expected from, a storage battery equipment based on conditions similar to those obtaining on the Third Avenue Railway, New York.

The manufacturer assumes that the car measures 22 feet over the body and seats 30 passengers on longitudinal seats; total weight of car, including battery, 7 tons; maximum speed on level track, about 15 m. p. h.; schedule speed, 7 m. p. h., number of stops, seven or eight per mile; track to be fairly level.

The battery would consist of 58 No. 29-MV Hycap-Exide cells similar to those installed on 50 Third Avenue cars. The cells in these cars are assembled in fourteen four-cell trays and two single-cell trays. The total weight of the battery is 4,876 lb.; and the capacity 67 amp. for six hours at an average of 114 volts. The over all dimensions of one of the four-cell trays are 10.875 in. x 27.75 in.

In some cases it may be preferable to assemble the cells in two-cell trays to facilitate handling. This will add slightly to the total space and very slightly to the weight. The capacity of this battery under the conditions of service hereinbefore specified should give a performance of 90 to 100 miles on one charge. Such a car would readily ascend a 7 per cent. grade with a full passenger load and would handle a 20 ft. trailer on short runs and on grades not exceeding 3 per cent.

The cost of the battery above specified is $1570 f. o. b. factory. The cost of battery maintenance under the conditions above described would not exceed from 3 to 4 cents per car mile. This figure should cover the entire upkeep, so that there would be no additional item for depreciation.

In regard to the capacity of the lead cell, it is well to point out that while the ampere-hour capacity is reduced by increasing the discharge rate provided the discharge is continuous, this is not true of intermittent work. Where the discharge is intermittent and is extended over a long time with periods of rest between the discharges, practically full ampere-hour capacity can be obtained even though the rate of discharge be comparatively high. Furthermore, the capacity of a battery increases for some little time after it is first put into service, falling off again toward the end of its life to its initial capacity; thus the average capacity of the battery in service is somewhat greater than the initial capacity. The watt-hour efficiency of the battery, if properly handled, should not fall below 70 per cent. in actual service.

Water will have to be added to the cells at certain intervals, say once a week. In many cases the local water supply is sufficiently pure for this purpose and it will not be necessary to provide distilled water. If the local supply is not sufficiently pure, provision can often be made for collecting rain water for this purpose.

In many cases a smaller battery than that specified above will be found adequate to meet the requirements, especially if the schedule permits giving the battery one or more "boosting" charges. These "boosting" charges if properly handled, are not injurious. The permissible rate of charge depends upon the state of charge of the battery. If the battery is empty, one-half of its rated capacity may be restored in one hour, or full capacity in three hours.

On the Third Avenue system the batteries are charged mostly at night without removal from the cars, and no intermediate or "boosting" charges are given between trips during the hours of service. It is not true that the lead battery is injured by these "boosting" charges, or by charging at high rates.

Several double-truck cars equipped with this type of battery are now under construction. One of these is a car 39 ft. over all, designed to weigh 31,000 lbs., including battery. It will be provided with 88 cells having a capacity of 67 amp. for six hours continuous discharge at an average of 173 volts. The maximum speed will be 25 m. p. h. on level track, and the total performance on one charge of the battery is to be 60 miles.

The foregoing data apply to the Hycap-Exide type of battery. The Ironclad-Exide type, which was put on the market by The Electric Storage Battery Company early in 1911 for vehicle work, has not yet been put into service on storage battery cars. It is believed, however, that this type is well adapted to this class of service; and that while greater in first cost, it will reduce the total annual charges on account of the reduced renewal expense.

THE GENERAL ELECTRIC COMPANY'S GAS-ELECTRIC CARS

The self-propelled cars offered by the General Electric Company are of the gasoline-electric type, and like the McKeen gasoline cars have not been developed for city service. This company advocates the gasoline-electric combination for the following reasons:

Electric drive is more flexible, full engine output may be had regardless of car speed, car may be driven from more than one axle, rigid wheel base may be made short, smoother acceleration and use may be made of motors to stop car in event of brake failure. Smoother speed changes, engine spring mounted and more accessible; hence easier to inspect and adjust.

The maintenance is lower due to fewer shocks to apparatus, location of apparatus admits of more water and gasoline connections and minimum maintenance expense on electrical equipment.

The simplicity of control and operation, ability to reverse car without stopping the engine, and, compared to a locomotive, the

lower operating cost are obviously features that are particularly advantageous to this type of car.

The General Electric Company's latest gas-electric car is propelled by an eight cylinder V-type gasoline engine of 175 hp.

FIG. 14. OPERATION OF GAS-ELECTRIC MOTOR CAR — GENERAL ELECTRIC COMPANY.

direct-connected to which is a 600 volt commutating pole generator. On the front truck directly under the engine and generator are two GE-205 railway motors, which by means of a suitable controller are placed progressively in series and in parallel. There

is no resistance in the motor circuit, the control being effected by varying resistance in the generator field, which is accomplished by the same series-parallel controller. The engine and generator are mounted on helical springs, which obviates vibration in the carbody, and avoids hammer blows to the power plant when passing over crossings or switches.

The engine is cooled by water passing through radiators on the cab roof, by means of the thermo-syphon system, no pump being required. The lubrication is positive, being under pressure. The engine is started by compressed air, the initial charge for which is

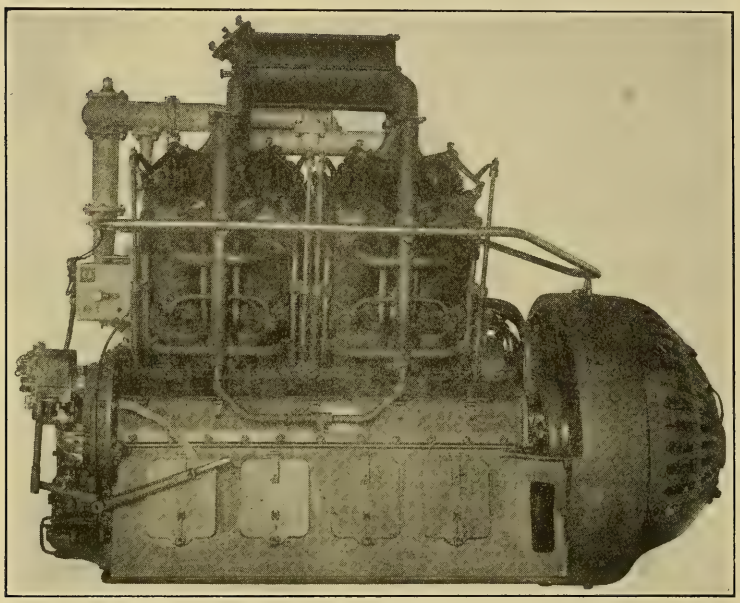


Fig. 15. Side View of General Electric Company's Power Plant.

obtained from an auxiliary gasoline engine compressor of 10 hp., and after the first start the air for the brakes, whistle, and bell, as well as for subsequent starts, is maintained by the main engine, which has a compressor on the crank shaft. A governor controls the air at the desired pressure.

To the auxiliary engine is direct-connected a 1.5 kw. generator which serves to light the car. This engine is governed, which is not the case with the main engine; it is hand throttled only, the throttle being placed on the controller just above the controller handle. The cars are heated by a coal fired hot water heater.

The largest type of car is 70 ft. over bumpers, and comprises the cab, baggage room, smoker, and main compartment, and with 11 ft. of baggage space will seat 91 passengers. A variety of car-body designs include a standard rear-entrance type; center-entrance

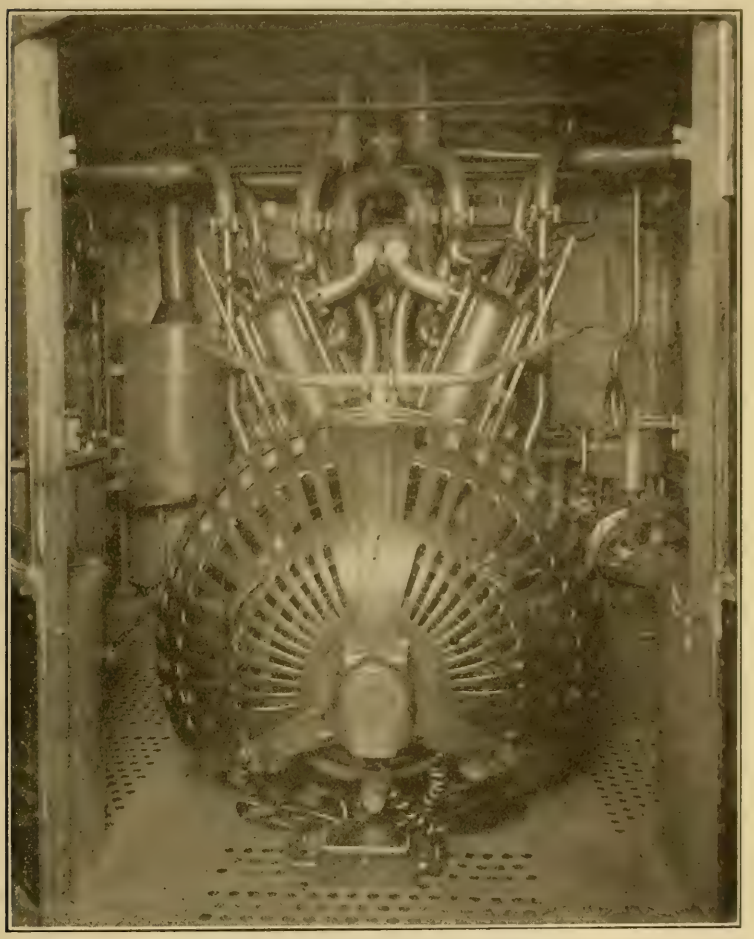


FIG. 16. INTERIOR OF CAB — GENERAL ELECTRIC COMPANY'S GAS-ELECTRIC CAR.

type with rounded rear observation end; a type having both center and rear entrances, for use principally in the South; and a type having the center-entrance and a door in the rear to pass into

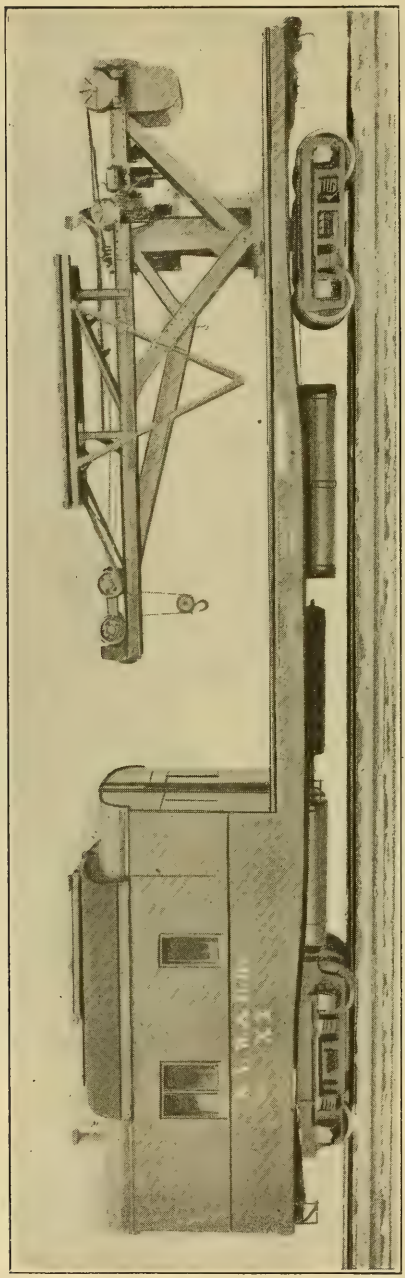


FIG. 17. GAS-ELECTRIC CONSTRUCTION CAR BUILT BY GENERAL ELECTRIC COMPANY.

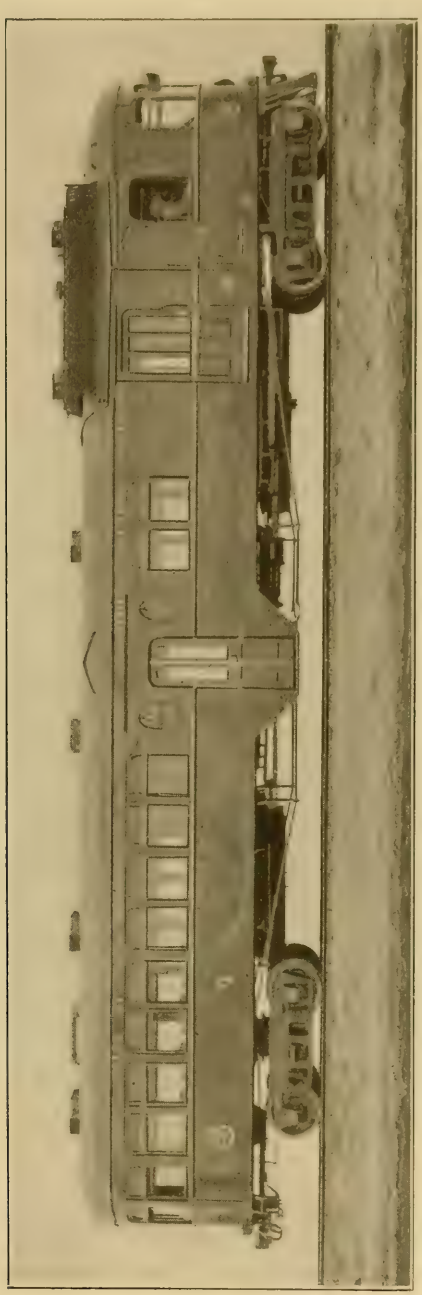


FIG. 18. GAS-ELECTRIC MOTOR CAR BUILT BY GENERAL ELECTRIC COMPANY — TYPE C. E.-50-B-8.

a trailer, but no platform on the rear. The approximate net weight of one of these cars in operating condition is 51 tons, 60 per cent. of which is on the front, or motor truck, and available for traction.

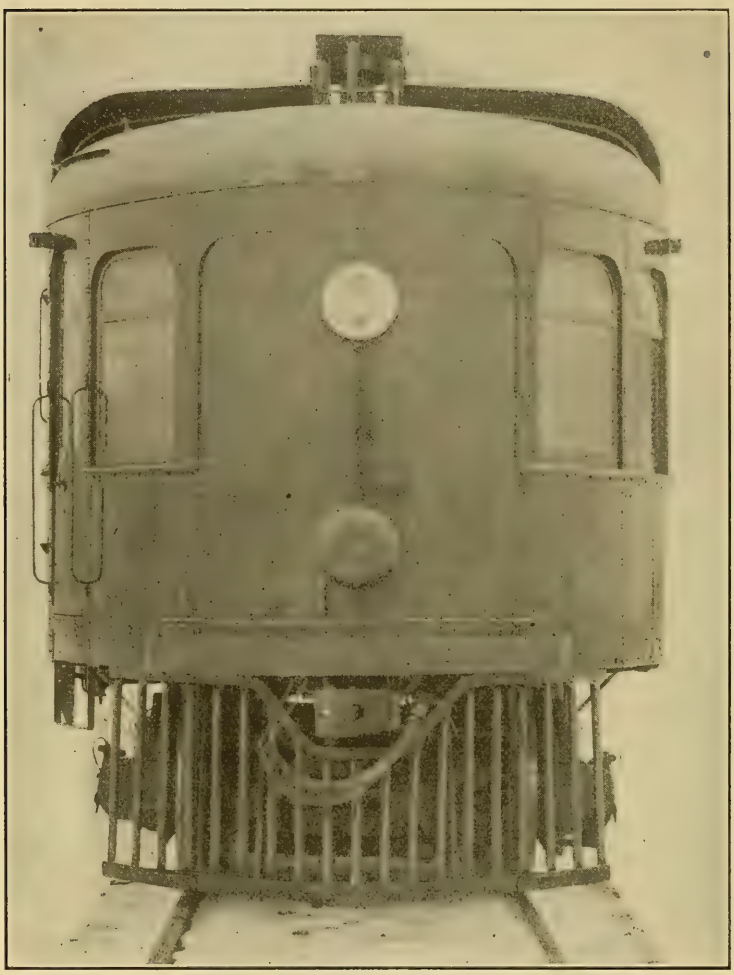


Fig. 19. End View of General Electric Company's Gas-Electric Car.

In addition to these standard types of cars, there has been developed and built a type of construction car, having the same power plant in the forward end, and an electric crane on the rear

end, which has proved itself remarkably successful on account of ease and rapidity of operation. One of these cars is used by the New York, Westchester & Boston (single-phase) Railway.

Some of the roads operating the General Electric Company's gas-electric cars are the following:

Southern Railway.
Buffalo, Rochester & Pittsburgh Railway.
Minneapolis, St. Paul, Rochester & Dubuque Electric Traction Company.
St. Louis, Brownsville & Mexico Railway.
Orange & Northwestern Railroad.
New Orleans, Texas & Mexico Railroad.
St. Louis, San Francisco & Texas Railway.
Louisiana Southern Railway.
New Iberia & Northern Railroad.
Bangor & Aroostook Railroad.
Delaware & Hudson Company.
Gary, Hobart & Eastern Traction Company.
Missouri Pacific Railway.
Canadian Northern Railway.

As regards cost of operation, a summary of the Minneapolis, St. Paul, Rochester & Dubuque Electric Traction Company ("Dan Patch Lines") from August, 1911, to March, 1912, inclusive shows as follows:

	Per car mile
Wages	$0.0447
Fuel	0.0400
Other expenses	0.0410
Total operating cost	$0.1257

The above includes under "other expenses" engine oil, journal oil, cleaning, superintendence, inspection, maintenance, heating shops as well as cars, etc.—in fact the figures cover all direct operating expenses. The "Dan Patch Line" was chosen as an example owing to the fact that it operates eight of these cars. It would be difficult to strike an average of costs on other lines, owing to the great differences in the conditions.

The detailed figures upon which the foregoing summaries are based follow herewith:

TABLE XIV.— OPERATING COST IN CENTS PER TRAIN MILE, OF 51 TON GASOLINE-ELECTRIC CARS ON MINNEAPOLIS, ST. PAUL, ROCHESTER & DUBUQUE ELECTRIC TRACTION COMPANY LINES FOR PERIOD AUGUST, 1911, TO MARCH, 1912, INCLUSIVE.

ITEM	August, 1911	September, 1911	October, 1911	November, 1911	December, 1911	January, 1912	February, 1912	March, 1912	Average per month
Mileage	16,245	15,966	14,556	15,103	15,487	13,716	14,198	14,905	15,022
Trailer mileage	2,482	3,023	.....	.....	.....	.....	.....	.....	.....
Gasoline, gallons used	9,887	9,920	9,024	9,076	9,359	8,920	8,857	8,361	9,175.5
Approx. 6.32 cents per gal.	3.8	3.72	3.9	3.8	3.82	4.11	4.25	4.67	4.01
Engine oil, gallons used	294	327	376	515	396	257	340	296	350
Approx. 23.4 cents per gal.	0.47	0.49	0.60	0.80	0.59	0.44	0.56	0.47	0.526
Journal oil, gallons used	90	85	58	54	56	52	46	45	60.8
Approx. 7.2 cents per gal.	0.04	0.04	0.03	0.02	0.03	0.03	0.03	0.02	0.03
Car maintenance	.....	0.02	0.37	0.27	0.45	0.45	0.61	1.29	0.433
Waste, soap, car-heating, lamp renewals, etc.	0.04	0.41	0.64	0.60	0.93	0.96	1.05	0.81	0.68
Superintendence, inspection, electrical maintenance, shop and car cleaning	2.51	1.36	1.86	2.51	2.66	2.84	2.76	2.97	2.434
Wages, crew	5.38	6.10	4.90	4.03	3.94	3.88	3.31	3.89	4.443
Gallons of gasoline per train mile	0.608	0.620	0.620	0.604	0.604	0.650	0.624	0.560	0.611
Gallons of engine oil per train mile	0.018	0.020	0.027	0.034	0.026	0.019	0.024	0.020	0.0235
Total operating cost	12.24	12.14	12.30	12.03	12.42	12.71	12.57	14.12	12.56

The following Table XV is a comparison of the several types of gasoline-electric cars which have been developed by this company, excepting the trial car built for city service on the lines of the Third Avenue Railway, New York:

TABLE XV.—TYPES OF GENERAL ELECTRIC CARS

CAR DIMENSIONS	First 65 feet long, 9 feet 8 inches over sills	Second steel 49 feet long, 8 feet 8 inches wide	Third 50 feet long	Present type 70 feet long
Compartments	Engine room, baggage room, smoking room, main saloon.	Divided like the first car.	Divided like the first car.	Divided like the first car but has negro compartments also.
Seating capacity	40	45	45	90
Lighted	Exciter	Exciter and storage.	Exciter and storage.	Auxiliary engine.
Heated	Cooling water of engine.	Cooling water of engine.	Cooling water	Coal-fired, hot-water heater.
Weight	68 tons	31 tons	36 tons	50 tons.
Trucks	Forward, special 36 in. wheels; rear, s't'd. M. C. B.	Both alike one motor on each.	Alike	Alike.
Engine	Six cylinder horizontal opposed 140 hp., 430 Wolseley gas engine started by cartridge.	Eight cylinder, V-type, 100–550 started by cartridge.	Eight cylinder, V-type, 125–550 started by air.	Eight cylinder, V-type 175, started by air.
Ignition	Storage and magneto make and break.	High tension, magneto jump spark.		
Gasoline	Pressure system.	Supplied by pump. No pressure.		
Cooling	Pipes and radiator on roof of car.	Radiator on roof.		
Generator	T. D. 600–125 exciter mounted on frame.	T. D. 500–125 exciter mounted on generator shaft.		80 kw. No exciter.
Motors	2-GE-69	2-GE-72	2 motors on one truck.	2 motors on one truck.
Controller	Special with relay for short circuiting resistance in generator field. Automatically as car accelerates.	C type serves parallel and variation of generator voltage by cutting resistance in and out of exciter circuit and varying engine speed.		Cut out resistance of generator field and throttle control.
Brakes	Standard G. E. combined straight and automatic air brake.	Standard straight and automatic air brakes.		
Compressor	Motor-driven	Motor-driven	Auxiliary engine and pump on main shaft.	Auxiliary engine.

The General Electric Company does not expect to see self-propelled cars hauling heavy trains on through service, as such work is beyond their field. What it does expect to see is that all the low-traffic branch lines throughout the country will ultimately be operated by them, to provide at reduced cost a better service than can possibly be had with the dirt and smoke producing steam locomotive.

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SUPPLEMENTARY DATA FOR REPORT ON SELF-PROPELLED CARS

(A) — Gasoline Cars:— The following table shows the average operating costs in cents per mile for five McKeen gasoline cars for a period of three months:

	Cost per mile in cents
Repairs per mile	2.21
Gas	3.64
Motorman	3.16
Conductor and Baggageman	3.02
Oil waste, etc.	1.52
	13.55

(B)— Gasoline Electric Cars: — The French Westinghouse Company furnished data recently on two installations as follows:

Dinard & St. Briac Tramways, wooden car body with steel underframe and sheet steel panelling, 36.8 ft. long, 6.8 ft. wide, 10.7 ft. high, divided into five compartments as follows: machinery, central platform with standing room for 10 to 12; second class, seating 18; first class, seating 6; rear platform. The equipment consists of a 50 kw. d. c. variable speed generator direct-connected to a six-cylinder Benzol engine with the necessary motors, all mounted on one driving truck. The control is effected by a throttle, field and series parallel connection of the motors. The car is heated by the cylinder cooling water and lighted by acetylene. It weighs approximately 19.5 tons and can be run on 0.3 gal. of benzol per mile. With one controller the total weight is 27.5 tons in which case the benzol consumption is about 0.3 gal. per mile. In either case the amount of lubricating oil is about 0.01 gal. per mile.

The Mines de Carvin Railway has a somewhat heavier car, although the equipment is similar, consisting of 2-35 kw. d. c. variable speed generator direct-connected to a four-cylinder 60-hp. engine. The weight of the motor car is approximately 24 tons while that of the trailer is 15.4 tons. The petrol consumption is approximately 0.17 gal. per train mile. On both of these roads the cost of fuel as compared with the former steam locomotive has been reduced nearly 50 per cent. It has also resulted in a reduction of train crews and more frequent and satisfactory service on account of increased readiness to serve.

(C)— Storage Battery Cars: — The accompanying Tables 3A and 3B contain data covering equipment and operating features of a number of Edison-Beach installations and records of test runs. These tables show that the weight of cars in operation ranges from 6.6 tons to 19.3 tons and that the total mileage is as high as 264 miles. The cars are operated under a wide variety of stops per mile, the range being from two to thirteen, which accounts for the range of energy consumption from 29.5 watt hours per ton mile to 85 watt hours per ton mile. The highest speeds with single car operation is given as 25.1 m. p. h. and the maximum grade as 8 per cent. The energy consumption of all Edison-Beach cars is very low owing to the extensive use of anti-friction devices such as ball bearings in motors and the use of the "Rollway" wheel which is direct-driven and mounted so as to revolve on the axle.

TABLE III-A — DATA ON EDISON-BEACH CARS.

Trip or road	Weight of car in tons	Voltage	Number of motors	Daily mileage	Stops per mile	Passengers per		Output watt hours per		Max. grades, per cent	Average speed in M. P. H.
						Day	Car mile	Car mile	Ton mile		
28th and 29 Street R. R., New York	7.3	85	2	57.25	12.0	627	11.0	528.0	85.0	3½	.....
Washington, Spa Springs, & Gretta, R. R. Co., Wash., D. C.	7.0	85	2	144.00	4.0	864	6.0	455.0	65.0	8–7¼–6	.....
Atlantic City	7.8	85	2	14.40	6.0	266	18.0	347.0	45.7	.....	.....
Philadelphia R. T. Co	7.6	85	2	66.35	13.0	496	7.5	601.0	79.0	2½	.....
Pennsylvania R. R., Long Island	6.6	85	2	41.50	2.0	102	2.5	377.0	57.1	2¼	.....
Salisbury & Spencer, Concord, N. C.	7.0	85	2	99.00	11.0	665	6.6	452.0	64.5	6.8	.....
Suffolk Traction Co., New York	*7.0	85	2	110.00	5.0	678	6.2	355.0	50.7	4½ 3.8	.....
Average	7.0	85	2	76.07	7.5	528	7.0	445.0	63.4	.....	.....
West Orange (round trip)	17.2	220	4	8.00	1.5	.....	14.0	786.4	46.1	2.2	24.0
Forest Hill (round trip)	16.5	220	4	70.20	2.2	.....	7.0	823.0	49.6	1.9	25.1
Forest Hill (Middletown)	16.6	220	4	62.50	1.8	.....	9.0	819.3	48.7	2.35	19.3
Middletown-Goshen, Newberg Junc.	16.9	220	4	28.70	2.1	.....	12.0	557.6	33.0	1.25	19.7
Goshen-Harriman	16.9	220	4	22.30	2.2	.....	12.0	804.5	47.4	1.20	19.6
Newberg Junc.-Bergen	16.7	220	4	41.50	2.0	.....	10.0	651.2	39.0	1.80	16.0
West Orange	†16.9	220	4	79.00	1.5	.....	12.0	725.0	42.8	2.20	17.8
Average	16.8	220	4	41.60	1.9	.....	10.0	739.4	43.8	1.84	20.2

* Single truck cars 6½ tons.
† Double truck cars 16 tons.

The following Table III-B contains data on a few of the latest developments of the Edison-Beach single and double truck cars:

TABLE III-B.

Road	Daily mileage	Approx. Wt. in tons	Operating and Maintenance expense (cents)	Energy consumption in watt hours per —		Length of line miles	Max. grade per cent
				Car mile	Ton mile		
Billings Traction Co..	75–140	7.4	7.0	385	52	.....	.....
Carolina Traction Co.	75–100	7.3	*10.0	536	74	3	3½
Wilmington, New Castle & Del. Co..	144–170	11.5	.....	557	48.5	11	7
Lewisburg, Milton & Watsontown R. R..	130	17.4	10.63	612	36.3	.....	.....
Cambria & Indiana Ry.....	66	16.5	.....	487	29.5	13½	5
Chesapeake & Ohio Ry. Co.....	264	18.3	.....	743	41.2	.....	.....

*Estimated.

It is announced that the Erie Railroad Edison-Beach car operated on the Watchung branch, New Jersey, is operated at 15 cents per car mile, the expenses per car mile being divided as follows:

Wages, (conductor and motorman).....	$0.0546
Power	0.0200
Amortization of battery.....	0.0249
Upkeep of battery.....	0.0025
Repair of car.....	0.0332
Interest on complete car.....	0.0150
Total operating expense (less general expense)..	$0.1502

An important development of this type of car is the application of a multiple-unit control whereby such cars can be operated in trains. A three-car train has already been furnished to the United Railways of Cuba. The plan is to operate single cars for the greater part of the day and use trains during rush hours. It is apparent that one advantage of this scheme is that cars can be charged during the low traffic periods of the day. The following is a description of these cars.

Each car is a passenger car and seats 40 people. The general equipment is of the M. C. B. standard as to wheels, height of drawbar, draft gearing and air brakes. The train is equipped with a unique system of multiple-unit control and is driven by 210 cells of the Edison A-6 battery. In each car are also twenty cells of A-6 battery which perform the functions of lighting the train and energizing the master control circuit of the multiple-unit system. The air equipment is both storage air and regular straight air for operation with a locomotive.

The speed of this train is 30 m.p.h. with full load and the energy consumption per ton mile at this speed is 45 watt-hours. In test runs of cars on level track at a speed of 25 m.p.h. a current consumption of 27 watt-hours per ton mile has been observed. It is believed that this record has never been approached by any other method of driving. The rate of acceleration is 0.6 m.p.h.p.s.

Each car is equipped with four 200 volt, 37½ amp. motors. These motors are connected with gear and pinion to the hub of the respective wheel to which they are attached, the whole constituting a method of driving which has been applied during the last two years by the company on all of its cars because it has been found to be reliable and a real saver of energy. The weight of the cars complete, ready for operation is 37,000 lb. each. The platforms are so arranged that by closing the center and side doors and lowering the trap doors over the steps, the platform is entirely enclosed; the side doors may be opened and the trap doors thrown up to permit entrance and exit of passengers; or the center door may be opened and locked open, leaving a free aisle through the train with the side doors closed, thus making an enclosed vestibule.

The framing and general construction of the cars is unique. The underframing throughout is steel in angles and shapes. Side sills are inserted in a 6-in. steel channel and bolted thereto. The car framing proper is of white ash treated with a carbolic preparation. There is a double sheathing of cedar on the outside while the interior sheathing is of mahogany. The posts are sheathed also on the outside with cedar. The letterboard is of cedar. The car interior, window and doors are framed in mahogany. The roof consists of pressed steel carlines in one piece, cedar roof boards, composite headlining and an outer cover of 8 oz. duck. The lighting outfit consists of 20 c.p. headlights with parabolic reflector and sixteen 12 c.p. lamps for the interior lighting.

This is the first instance where a train of cars has been driven with a storage battery. In test trials conducted during September on the Erie Railroad tracks the train has been found to meet all requirements. One peculiarily interesting multiple-unit test was the following: Cars were uncoupled and moved apart about one foot and the air hose was disconnected, leaving only the two-conductor cable for operating the controller upon which the cars were operated up to maximum speed and yet were found to maintain their relative positions within about six inches, an excellent illustration of the perfection of the control system. In this control two conductors are used between cars with a ground return. If desired, even a single conductor would answer. The total equipment of the multiple-unit control including everything weighs 900 lb. About 400 lb. of this, however, is not essential and can be removed. This system does all of the things that a multiple-unit controller should do, such as making

the various combinations required for series-parallel control of the motors, resetting circuit-breakers, etc.

As a conclusion to this report, it may be appropriate to quote that on the same subject from a paper read by E. A. Ziffer, president, Bukowina Railway, Austria, before the International Street & Interurban Railway at Christiania, Norway, July 2 to 5, 1912. This paper is abstracted in the *Electric Railway Journal* for August 24, 1912. Mr. Ziffer also gave attention to both European and American developments in self-propelled cars. In conclusion he makes the following comments:

Steam, he states, has not made much notable progress. With the exception of the McKeen type, the straight gasoline type had been abandoned. The gas-electric car seemed to offer the most interesting possibilities at present as it was more flexible than other fuel combustion systems. The apparatus was easy to handle and the cost of fuel was little if a low grade of fuel was used. One great drawback was the large first cost which resulted in a high interest and amortization charge. The storage battery car had given successful service both in Germany and United States, but like the gas-electric car, it was still impossible to define its economic position. It might not be long, however, before some acceptable car was perfected.

Mr. Ziffer's conclusions corroborate your committee's opinion that it is yet too early to determine what type of car will prove most suitable. Each case should be studied by itself as it is difficult, if not impossible, to formulate general rules.

APPENDIX B

SPECIFICATIONS FOR FORGED OR ROLLED SOLID CARBON STEEL WHEELS FOR ELECTRIC RAILWAY SERVICE

RECOMMENDED FOR ADOPTION AS RECOMMENDED PRACTICE

PROCESS:

1. Steel for wheels shall be made by the open-hearth process.

DISCARD:

2. The ingots from which the blanks are made shall have sufficient discard to insure freedom from injurious pipes and segregation.

CHEMICAL COMPOSITION:

3. The steel shall conform to the following requirements as to chemical composition:

Carbon	0.65 to 0.85 per cent
Manganese	0.60 to 0.80 per cent
Silicon	0.10 to 0.30 per cent
Phosphorus, not over	0.05 per cent
Sulphur, not over	0.05 per cent

SAMPLE FOR CHEMICAL ANALYSIS:

4. Drillings to determine the uniformity of the chemical contents of the wheels may be made by drilling through the plate of one wheel, selected at random from each heat, four ½ in. holes, 90 deg. apart and within 3 in. inside of the rim of wheel; drillings to be clean and free from scale and dirt.

These drillings may, at the discretion of the Engineer, be analyzed separately to determine the segregated area, showing non-uniformity of material, and any of the four samples from the wheel must be within the limits prescribed in Paragraph 3 and not vary more than 5 points from each other in carbon.

For mating purposes only, if the average of the four drillings shall differ more than 5 points in carbon from the heat analysis, then two more wheels from the same heat must be drilled and analyzed as above, and the average of the carbon found in the 12 drillings substituted for the heat analysis.

ANALYSIS FURNISHED:

5. Manufacturers shall furnish to the purchaser or his representative a complete analysis of each heat unless otherwise arranged. These analyses shall conform to the limits prescribed in Paragraphs 3 and 4 and a complete record of each shipment shall be mailed direct to the purchaser.

FINISH:

6. All wheels shall be free from injurious seams, cracks, flaws or other imperfections detrimental to strength or service. Wheels for inspection must not be painted or covered with any substance in any way to hide defects, nor rusted to such an extent as to hide defects.

WORKMANSHIP:

7. Wheels shall be machined on both sides of hub, back of rim, contour and face of rim, rough bored and shall conform to dimensions shown in drawing No. —— approved by the purchaser and subject to tolerances herein provided; or if specified by the purchaser, wheels may be furnished with the contour as rolled, provided they conform to the dimensions and tolerances specified and as shown in Fig. 1, page 99, part of these specifications.

Height of Flange:

7(*a*) The height of flange shall not vary more than 1/32 in. (for machined wheels), nor more than 1/16 in. (for rolled wheels), in either direction from that specified.

Thickness of Flange:

7(*b*) The thickness of flange shall not vary more than 1/32 in. (for machined wheels), or more than 1/16 in. (for rolled wheels), in either direction from that specified.

Radius of Throat:

7(*c*) The radius of throat shall not vary more than 1/32 in. (for machined wheels), or more than 1/16 in. (for rolled wheels), in either direction from that specified.

Thickness of Rim:

7(*d*) The thickness of the rim shall not be more than ¼ in. over nor more than ⅛ in. under that specified. The thickness of rim shall be measured from a base line drawn from the intersection of the throat radius to the tread, parallel to the axis of the wheel.

Width of Rim:

7(*e*) The width of rim shall not vary more than 1/16 in. (for machined wheels), or more than ⅛ in. (for rolled wheels) in either direction from that specified.

Thickness of Plate:

7(*f*) The thickness of plate shall not vary more than ⅛ in. less than that specified and within the prescribed weight limits over that specified as given in paragraph 7(*s*).

Limit Groove:

7(*g*) When limit groove is specified the location of the center of limit-of-wear groove shall not vary more than 1/16 in. from that specified.

Diameter of Bore:

7(*h*) The diameter of rough bore shall not vary more than 1/16 in. over nor ⅛ in. less than that specified. When not specified, the diameter of rough bore shall be ¼ in. less in diameter than the finished bore, subject to the above limitations.

Diameter of Hub:

7(*i*) The diameter of hub shall be no less but may be ⅜ in. more than that specified, but the thickness of wall of the finished bored hub shall not be less than 1 in. at any point for bores 6 in. in diameter and under, and no less than 1¼ in. for bore more than 6 in. unless otherwise specified.

Length of Hub:

7(*j*) Length of hub shall not vary more than 5/32 in. from that specified.

Projection of Front Face of Hub:

7(k_1) The projection of front face of hub from the gauge line shall not vary more than ⅛ in. from that specified.

Projection of Back Face of Hub:

7(k_2) The projection of back face of hub from gauge line of the wheel shall not be more than 1/32 in. from that specified.

Black Spots on Hub:

7(*l*) Black spots deeper than 1/16 in. will not be permitted in rough bore within 2 in. of either face of the hub.

Eccentricity of Bore:

7(*m*) The eccentricity of bore between the center line of tread and center line of rough bore shall not exceed 3/64 in.

Block Marks on Tread:

7(*n*) Block marks shall not exceed 1/64 in. in height.

Rotundity:

7(*o*) The wheels shall be gauged with a ring gauge, and the opening between the gauge and tread at any point shall not exceed 1/32 in.

Plane:

7(*p*) Wheels shall be gauged with a ring gauge concentric with and perpendicular to the axis of the wheel. All points on the gauge line equidistant from the center, and the center line of throat, and

flange and all points must bear the same relation to the plane ring gauge as the back of the flange does to the ring. Such measurement shall be within a variation of 1/32 in. (for machined wheels), or 1/16 in. (for rolled wheels), from the plane of the gauge when so placed.

Tape Sizes:

7(*q*) The wheels shall not vary more than four tapes under nor six tapes over the size specified.

Mating:

7(*r*) All wheels shall be measured by standard tape and have the tape numbers clearly marked or stenciled on the web of each wheel. The wheels shall be mated first to carbon so that the material of each pair of wheels shall be the same, then to tape size and shipped in pairs. No wheels in the same pair shall have more than ⅛ in. or one tape difference in circumference and no more than 0.02 difference in the carbon, based on the analyses as described in Paragraph 4.

Weight:

7(*s*) The weight of wheel shall not exceed the maximum estimated weight more than given below. For calculation, take the correct figures from the approved drawing using 5 in. rough bore:

For all wheels up to and including 34 in. diameter, 7 per cent.

For all wheels above 34 in. diameter, 8 per cent.

Tolerance Gauge:

7(*t*) In order to determine the location of gauge line, a template shall be constructed in conformance with drawing No. ——, referred to in Paragraph 7 and illustrated in Fig. 2, page 100.

GAUGES AND TAPES:

8. The manufacturer shall provide suitable gauges and tapes which shall conform to contour and dimensions shown in drawing No. —, and approved by the purchaser.

BRANDING:

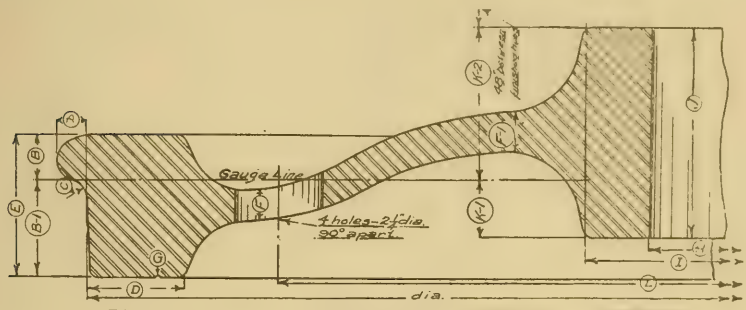
9. Wheels shall be stamped with the manufacturer's mark, the serial number of the wheels, indicating the location of the wheel in the ingot and the heat; and C — T and Pr. while hot in such a manner that each wheel may at any time be readily identified.

The carbon stenciled at the place stamped "C"; tape size at the place stamped "T"; pair number may be painted at the place stamped "Pr."

Arrangement of marking is shown in Fig. 3, page 769.
All wheels to be shipped in pairs.

INSPECTION:

10(*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wheels ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities



Ref. Letter	Dimension		Specified Tolerances over	under	Ref. Letter	Dimension		Specified Tolerances over	under
Dia.			Tape Size 6	4	F			—	1/8"
					F-1			—	1/8"
A		Machined	1/32"	1/32"	G			1/16"	1/16"
		Rolled or Forged	1/16"	1/16"	H			1/16"	1/32"
B		Machined	1/32"	1/32"	I			3/8"	0
		Rolled or Forged	1/16"	1/16"	J				
B-1		Machined			K-1			1/8"	1/8"
		Rolled or Forged			K-2			1/32"	1/16"
C		Machined	1/16"	1/16"	L				
		Rolled or Forged	1/8"	1/8"	Weight		5" Rough Bore	7/0	—
D		Machined	1/4"	1/8"					
		Rolled or Forged	1/4"	1/8"					
E		Machined	1/32"	1/32"					
		Rolled or Forged	1/16"	1/16"					

FIG. 1. SHOWING DIMENSIONS AND TOLERANCES FOR STEEL WHEELS.

to satisfy him that the wheels are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

10(*b*) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

10(*c*) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

10(*d*) Wheels, which show injurious defects while being finished by the purchaser, will be rejected, and returned to the manufacturer, who shall pay return freight.

10(*e*) Unless otherwise arranged, any rejection based on tests made in accordance with section 10(*b*) shall be reported within 10 working days from the receipt of wheels.

10(*f*) Samples tested in accordance with section 10(*b*), which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the

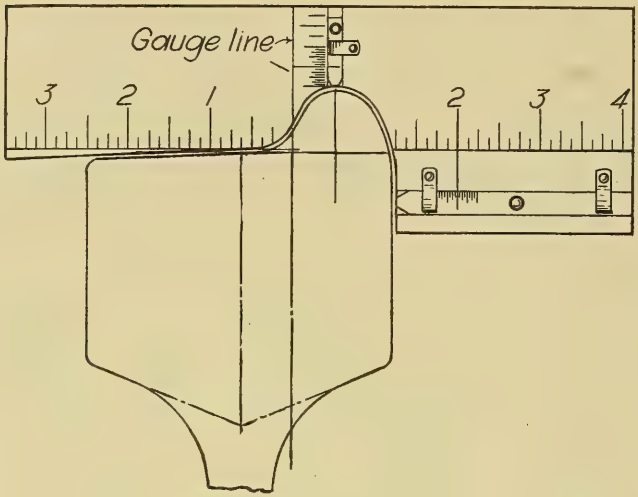


Fig. 2. Showing Tolerance Gauge.

results of the tests, the manufacturer may make claim for a rehearing within that time.

10(*g*) The term "Rolled Wheels," shall be interpreted to mean rolled or forged.

10(*h*) The manufacturers shall replace free of charge, any wheels sold, delivered and manufactured under these specifications that may prove defective by reason of cracks, breaking, defective material or workmanship.

The manufacturers also agree further to protect the purchaser from any and all patent litigations and will defend all suits at his

own expense which may be brought when patent infringement is claimed. The purchaser further agrees to forward notice of such patent suits upon receipt of same. Drawing No. ——, approved by the purchaser is part of these specifications.

NOTE.—Marking on back of plate; Manufacturer's Name, Number, C., T. and Pr., stamped in hot wheel. Carbon and tape size stenciled. Pair No. painted.

FIG. 3. SHOWING BRANDING OF WHEELS.

APPENDIX C

PROPOSED REVISION OF STANDARD SPECIFICATIONS FOR HEAT-TREATED CARBON STEEL AXLES, SHAFTS AND SIMILAR PARTS.

RECOMMENDED FOR ADOPTION AS STANDARD BY THE 1911 COMMITTEE ON HEAVY ELECTRIC TRACTION AND APPROVED BY THE 1911 CONVENTION AND 1911 COMMITTEE ON STANDARDS.

PROCESS OF MANUFACTURE:

1. Steel under this specification shall be made by the open-hearth or other approved process.

DISCARD:

2. A sufficient amount of discard must be made from each ingot to insure freedom from piping and undue segregation.

CHEMICAL COMPOSITION:

3. The steel shall conform to the following limits in chemical composition:

Carbon	Not over 0.60 per cent.
Manganese	0.40 to 0.80 per cent.
Phosphorus	Not over 0.04 per cent.
Sulphur	Not over 0.05 per cent.

SAMPLES FOR CHEMICAL ANALYSIS:

4. Drillings shall be taken from the crop end of one axle, shaft, or similar part from each melt represented, parallel to the axis on any radius one-half the distance from the center to circumference, to determine whether the chemical composition of the heat is within the limits specified in Paragraph 3.

In addition to the complete analysis, the purchaser may have a phosphorus determination made from the turnings or borings taken from each tensile test specimen, and the phosphorus in every specimen must not be more than 25 per cent. above the limit given in Paragraph 3.

TENSILE TEST:

5. The steel shall conform to the following minimum physical properties:

Ultimate strength, lb. per sq. in.	85,000
Elastic limit, lb. per sq. in.	50,000
Elongation in 2 in., per cent	22
Reduction of area, per cent	45

The elastic limit shall be determined by extensometer. Above 40,000 lb. per sq. in., each increment of load shall be not more than 1,000 lb. per sq. in.

SPECIMEN FOR TENSILE TEST:

6. The test specimen as shown by Fig. 1, 0.5 in. diameter and 2 in. gauge length, shall be used to determine the physical properties as specified in Paragraph 5. Test specimens shall be taken from the crop end of one axle, shaft, or similar part, from each treating-plant heat; if more than one open-hearth heat is represented in a treating-plant heat, a test shall be taken from each open-hearth heat represented. A full-size prolongation shall be left on each axle, shaft, or similar part.

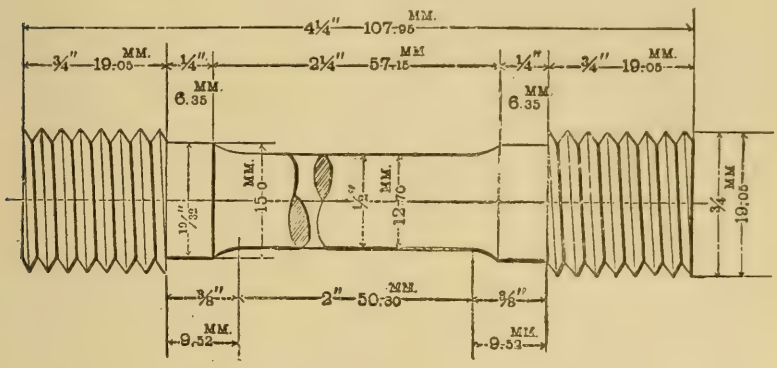


FIG. 1. SHOWING SPECIMEN FOR TENSILE TEST.

COLD BEND TEST:

7. A cold bend test shall be made from the crop end of one axle, shaft, or similar part, from each treating-plant heat; if more than one open-hearth heat is represented in a treating-plant heat, a test shall be taken from each open-hearth heat represented.

The test shall be made with a ½ in. square specimen not exceeding 6 in. in length, around a 1 in. flat mandrel, having a rounded edge of ½ in. radius, and the specimen shall bend without fracture 180 deg. around said mandrel. The test shall be made by steady pressure or by blows. The form and dimensions of the mandrel are shown in Fig. 2.

LOCATION OF SPECIMENS FOR TENSILE TEST AND COLD BEND TEST:

8. Specimens for tensile test and cold bend test shall be taken parallel to the axis of the axle or shaft and on any radius one-half the distance from the center to the circumference.

RETESTING:

9. In case the physical results obtained from any lot of axles, shafts, or similar parts, do not conform to those called for in

Paragraphs 5 and 7, the manufacturer shall have the privilege of retesting such parts, from which new tests shall be taken by the purchaser, and these shall govern the acceptance or rejection of the lot.

HEAT TREATMENT:

10. Each axle, shaft, or similar part shall be allowed to become cold after forging, shall then be reheated to the proper temperature, quenched in some medium, allowed to cool, and then reheated to the proper temperature for annealing.

HEAT TREATMENT:

11. Warped axles or shafts or similar parts must be straightened hot; that is, at a temperature above 900 deg. Fahr., and before offering the parts for test.

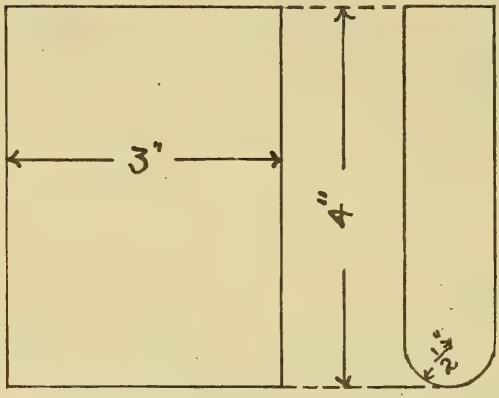


FIG. 2. SHOWING FORM AND DIMENSIONS OF MANDREL.

QUALITY:

12. All axles, shafts, and similar parts shall be free from cracks, flaws, seams, or other injurious imperfections when finished. Those which show such defects while being finished by the purchaser will be rejected and returned to the manufacturer, who must pay return freight.

FINISH:

13. All axles, shafts, and similar parts must be rough-turned with an allowance of 1/8 in. on surface finishing, except on axle collars, which are to be left rough-forged. Turning must be done on 60 deg. centers with clearance drilled at point.

BRANDING:

14. The heat number shall be stamped on the rough-forged collar. After rough-turning, the manufacturer's name, heat number, individual axle or shaft number, and inspector's mark shall be stamped at a place indicated by the purchaser, except at any point between the rough collars.

INSPECTION:

15. The inspector representing the purchaser shall have free entry, at all times while his contract is being executed, to all portions of the manufacturer's shop which concerns the manufacture of material ordered. All reasonable facilities shall be afforded to the inspector by the manufacturer to satisfy him that the axles, shafts, and similar parts are being furnished in accordance with the specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and free of cost to the purchaser. The purchaser shall have the right to make tests to govern the acceptance or rejection in his own test room or elsewhere, as may be decided by the purchaser, such test, however, to be made at the expense of the purchaser, and to be made prior to the shipment of the material. Unless otherwise arranged, any protest based on such tests must be made within six days, to be valid. Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the mill.

APPENDIX D

PROPOSED STANDARD SPECIFICATIONS FOR COLD ROLLED STEEL AXLES

PROCESS OF MANUFACTURE:

1. Steel under this specification shall be made by the open-hearth or other approved process.

All axles must be cold rolled to finished size from hot rolled bars. Finished sizes must not vary more than two thousandths of an inch above or below the required size.

DISCARD:

2. A sufficient amount of discard must be made from each ingot to insure freedom from piping and undue segregation.

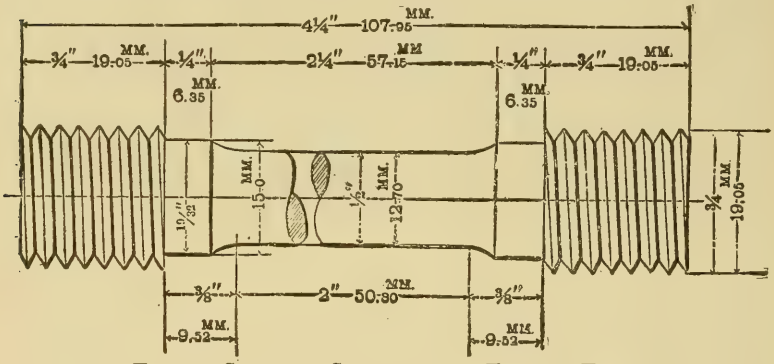


FIG. 1. SHOWING SPECIMEN FOR TENSILE TEST.

CHEMICAL COMPOSITION:

3. The steel shall conform to the following limits in chemical composition:

Carbon	Not over 0.40 per cent
Manganese	0.40 to 0.80 per cent
Phosphorus	Not over 0.04 per cent
Sulphur	Not over 0.04 per cent
Sulphur	*Not over 0.05 per cent*

SAMPLES FOR CHEMICAL ANALYSIS:

4. Drillings shall be taken from the crop end of one axle from each melt represented, parallel to the axis on any radius one-half the distance from the center to circumference, to determine whether the chemical composition of the heat is within the limits specified in Paragraph 3.

NOTE:—The changes in these specifications as recommended in the Supplementary Report of the Committee are shown in italics. (ED.)

In addition to the ladle analysis, the purchaser may have a phosphorus determination made from the turnings or borings taken from each tensile specimen, and the phosphorus in every specimen must be within 25 per cent. of the limit given in Paragraph 3.

TENSILE TEST:

5. The steel shall conform to the following minimum physical properties:

Ultimate strength, lb. per sq. in.	70,000
Elastic limit, lb. per sq. in.	60,000
Elongation in 2 in., per cent	18
Reduction of area	35

The elastic limit shall be determined by extensometer.

SPECIMEN FOR TENSILE TEST:

6. The test specimen, as shown by Fig. 1, 0.5 in. diameter and 2 in gauge length, shall be used to determine the physical properties specified in Paragraph 5. Test specimens shall be taken to represent each 50 axles, or less made from the same melt.

COLD BEND TEST:

7. A cold bend test shall be taken from each 50 axles, or less, made from the same melt. The test shall be made with a ½ in. square specimen, not exceeding 6 ins. in length, around a 1-in. flat mandrel having a rounded edge of ½ in. radius (Fig. 2), and the specimen shall bend, without fracture, 180 deg. around the said mandrel.

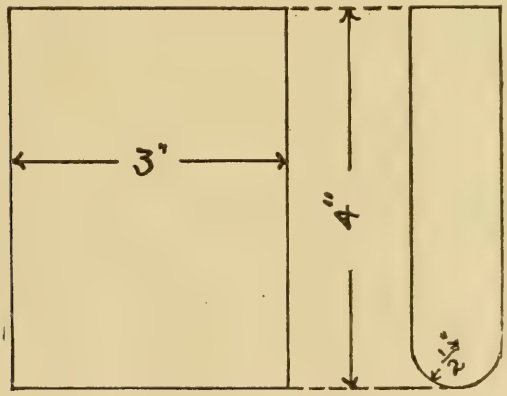


FIG. 2. SHOWING FORM AND DIMENSIONS OF MANDREL.

LOCATION OF SPECIMENS FOR TENSILE TEST AND COLD BEND TEST:

8. Specimens for tensile test and cold bend test shall be taken parallel to the axis of the axle and on any radius one-half the distance from the center to the circumference.

FINISH:

9. All axles, either finished or plain, shall be straight and free from cracks, flaws, seams or other injurious imperfections when finished. Those which show such defects while being finished by the purchaser will be rejected and returned to the manufacturer who must pay return freight.

CENTERING:

10. When centering is required, 60 deg. centers with clearance provided at point of shop lathe centers, shall be used unless otherwise specified.

BRANDING:

11. Each axle shall be stamped with the heat number, maker's brand and year. Unless otherwise indicated these marks are to be stamped at about the middle of the length of the axle.

The manufacturer shall also permit the inspector to place his stamp on each axle.

INSPECTION:

12. The inspector representing the purchaser shall have free entry, at all times while his contract is being executed, to all portions of the manufacturer's shop which concerns the manufacture of material ordered. All reasonable facilities shall be afforded to the inspector by the manufacturer to satisfy him that the axles are being furnished in accordance with the specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and free of cost to the purchaser. The purchaser shall have the right to make tests to govern the acceptance or rejection in his own test room, or elsewhere, as may be decided by the purchaser, such test, however, to be made at the expense of the purchaser and to be made prior to the shipment of the material. Unless otherwise arranged, any protest based on such tests must be made within six days, to be valid. Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the mill.

APPENDIX E

PROPOSED STANDARD SPECIFICATIONS FOR ANNEALED CARBON STEEL AXLES, SHAFTS AND SIMILAR PARTS

PROCESS OF MANUFACTURE:

1. Steel under this specification shall be made by the open-hearth or other approved process.

DISCARD:

2. A sufficient amount of discard must be made from each ingot to insure freedom from piping and undue segregation.

CHEMICAL COMPOSITION:

3. The steel shall conform to the following limits in chemical composition:

Carbon	Not over 0.60 per cent
Manganese	0.40 to 0.60 per cent
Phosphorus	Not over 0.04 per cent
Sulphur	Not over 0.04 per cent
Sulphur	*Not over 0.05 per cent*

SAMPLES FOR CHEMICAL ANALYSIS;

4. Drillings shall be taken from the crop end of one axle, shaft, or similar part from each melt represented, parallel to the axis on any radius one-half the distance from the center to circumference, to determine whether the chemical composition of the heat is within the limits specified in Paragraph 3.

In addition to the complete analysis, the purchaser may have a phosphorus determination made from turnings or borings taken from each tensile test specimen and the phosphorus in every specimen must not be more than 25 per cent. above the limit given in Paragraph 3.

TENSILE TEST:

5. The steel shall conform to the following minimum physical properties:

Ultimate strength, per sq. in	80,000 lb.
Elastic limit	44,000 lb.
Elongation in 2 in	22 per cent
Reduction of area	35 per cent

Elastic limit to be determined by extensometer.

SPECIMEN FOR TENSILE TEST:

6. The test specimen, as shown by Fig. 1, 0.5 in. diameter and 2 in. gauge length, shall be used to determine the physical prop-

NOTE:—The changes in these Specifications as recommended in the Supplementary Report of the Committee are shown in italics. (Ed.)

erties as specified in Paragraph 5. Test specimens shall be taken from the crop end of one axle, shaft, or similar part, from each annealed heat; if more than one open-hearth heat is represented in the annealed heat, a test is to be taken from each open-hearth heat represented. A full-size prolongation shall be left on each axle, shaft, or similar part.

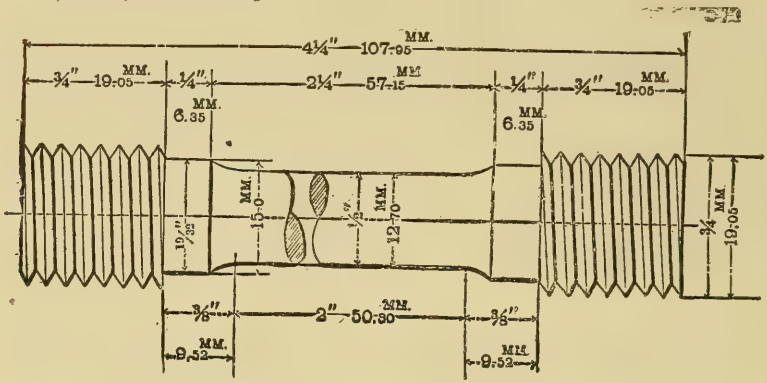


FIG. 1. SHOWING SPECIMEN FOR TENSILE TEST.

COLD BEND TEST:

7. A cold bend test shall be made from the crop end of one axle, shaft, or similar part from each heat; if more than one open-hearth heat is represented in a heat, a test shall be taken from each open-hearth heat represented.

The test shall be made with a ½ in. square specimen not exceeding 6 ins. in length, around a 1-in. flat mandrel, having a rounded edge of ½ in. radius, and the specimen shall bend without fracture 180° deg. around said mandrel. The test shall be made by steady pressure or by blows. The form and dimensions of the mandrel are shown in Fig. 2.

LOCATION OF SPECIMENS FOR TENSILE TEST AND COLD BEND TEST:

8. Specimens for tensile test and cold bend test shall be taken parallel to the axis of the axle or shaft and on any radius one-half the distance from the center to the circumference.

RETESTING:

9. In case the physical results obtained from any lot of axles, shafts, or similar parts do not conform to those called for by Paragraphs 5 and 7 the manufacturer shall have the privilege of reannealing such parts, from which new tests shall be taken by

the purchaser, and these shall govern the acceptance or rejection of the lot.

ANNEALING:

10. Each axle, shaft, or similar part shall be allowed to become cold after forging, shall then be reheated to the proper temperature for annealing, allowed to cool slowly in (furnace) *an approved manner.*

WARPED AXLES OR SHAFTS:

11. Warped axles or shafts or similar parts must be straightened hot; that is, at a temperature above 900 deg. Fahr., and before offering the parts for test.

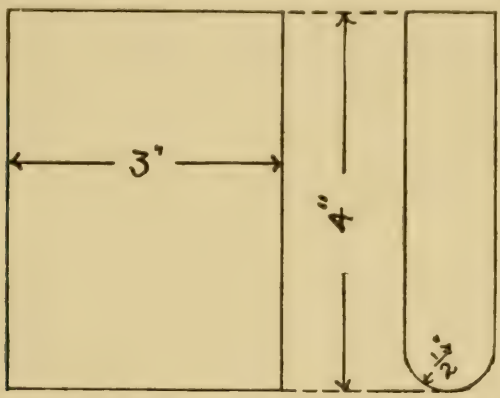


FIG. 2. SHOWING FORM AND DIMENSIONS OF MANDREL.

QUALITY:

12. All axles, shafts, and similar parts shall be free from cracks, flaws, seams, or other injurious imperfections when finished. Those which show such defects while being finished by the purchaser will be rejected and returned to the manufacturer, who must pay return freight.

FINISH:

13. All axles, shafts, and similar parts must be rough-turned with an allowance of ⅛ in. on surface for finishing, except on axle collars, which are to be left rough-forged. Turning must be done on 60 deg. centers with clearance drilled at point.

BRANDING:

14. The heat number shall be stamped on the rough-forged collar. After rough-turning, the manufacturer's name, heat num-

ber, individual axle or shaft number, and inspector's mark shall be stamped at a place indicated by the purchaser, except at any point between the rough collars.

INSPECTION:

15. The inspector representing the purchaser shall have free entry, at all times, while his contract is being executed, to all portions of the manufacturer's shop which concerns the manufacture of material ordered. All reasonable facilities shall be afforded to the inspector by the manufacturer to satisfy him that the axles, shafts, and similar parts are being furnished in accordance with the specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and free of cost to the purchaser. The purchaser shall have the right to make tests to govern the acceptance or rejection in his own test room, or elsewhere, as may be decided by the purchaser, such test, however, to be made at the expense of the purchaser and to be made prior to the shipment of the material. Unless otherwise arranged, any protest based on such tests must be made within six days, to be valid. Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the mill.

PRESIDENT ACKERMAN:—We will take up the discussion of the subjects presented by the Committee in the order in which they have been presented to us. The first subject which is before you for discussion is High Grade Rubber Insulating Compound.

Discussion of the Report of the Committee on Equipment

MR. RICHEY:—I move that the recommendation of the Committee on the subject of High Grade Rubber Insulating Compound be accepted.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:—The next subject is End Wear on Journals.

MR. ADAMS:—I move this portion of the report on End Wear on Journals be accepted as submitted by the Committee.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:—The next subject is Self-Propelled Cars. I will ask Mr. W. B. Potter, of the General Electric Company, to open the discussion on this subject.

MR. POTTER:— Discussion of this report on the subject of Self-Propelled Cars may very properly be prefaced by a compliment to the Committee for their excellent review and compilation of data covering a subject comparatively new to this Association. Their report merits commendation, as it bears evidence of a sincere effort to obtain all available information on this topic.

For the operation of self-propelled cars, the internal combustion engine or the storage battery appear to be better adapted than any other forms of motive power within our present knowledge. The proper field of application for the self-propelled car, with either form of power, is well covered by the conclusions in the report, the decision for any particular service being really a question of economic rather than technical consideration.

Self-propelled cars differ from the electric trolley in that they require further study than the selection of motors of suitable capacity and control equipment of the proper type. The engine-driven car has no operative limitation, but there are conditions under which it would be unfavorable because of the relative economy as compared to the storage battery. The storage battery on the other hand has the practical limitation of the distance over which it can propel the car from a single charge, and as this distance is proportional to the amount of battery carried, it becomes a question for determination in each instance as to whether the length of run can be economically performed. Generally speaking, the engine will be found more economical for the heavier equipments and, more particularly, for the longer runs, while the storage battery will be more economical for the lighter equipments and the shorter runs.

The cost of power whether in fluid form or electric energy is not only influenced by local conditions, but also affected directly by the weight of the equipment. This question of weight deserves more consideration than it has generally received for trolley service, and a reduction of weight to the minimum possible consistent with the required strength has been recognized as an essential in the development of self-

propelled cars and equipment. Minimum total weight of car is of even greater importance where storage batteries are used, not only because of the saving in power, but more especially on account of the greater distance that can be covered with a battery of given weight from a single charge. As evidence of the attention which has been given to reducing weight, the cars equipped with engines or with storage batteries, which in effect in both instances means adding the power station to the equipment otherwise required, will be found to weigh less per seated passenger than many trolley cars giving an equivalent service.

The control and motors for a storage battery car follow the same general principles as for a trolley car, although requiring particular attention to reduce friction losses for which reason ball or roller bearings are commonly used. The motor should be electrically designed to give the highest resultant efficiency, taking into account both the characteristic of the motor and the battery.

The internal combustion engine is essentially different in its power characteristic from either a storage battery or a steam engine. It has practically a constant torque regardless of the speed, and hence its power varies directly with the speed. By lengthening the cut off on a steam engine, maximum torque may be attained at low speed and by cutting out resistance or changing the motor connections the same is true of a storage battery. To obtain the higher torque at low speed, essential to the satisfactory acceleration of a car, it is necessary with the internal combustion engine to provide gearing of different ratios or its equivalent between the engine and driving wheels. This may be done mechanically, as is the usual practice in automobiles or electrically, by equipping the car with motors and supplying them with current from an engine driven generator, the voltage of which may be controlled by the operator.

Electrical control of this character not only provides a range of gear ratio between the engine and driving wheels which would be impracticable with mechanical drive, but is also free from the fixed ratios of gearing and obviously free

from the gear changing mechanism and complexity incident to mechanical drive. The power being transmitted electrically, the engine is wholly relieved from the shock and strain which would exist with mechanical drive, and thus, with the electric drive, the acceleration of the car or hauling of trailers imposes no greater duty on the engine than when driving the car at uniform speed.

The efficiency of mechanical drive considered simply as a power transmission is undoubtedly higher than the electric, but the higher efficiency of the electric drive during acceleration and its greater flexibility to meet varying conditions so far affects the net efficiency that the service consumption of fuel per car mile with either form of drive is practically the same.

Of direct interest to the operating company are facts with respect to the cost of operation, maintenance and depreciation of self-propelled equipments. Considerable information on these points is given in the report. On page 736 is given the cost of operation on the Minneapolis, St. Paul & Dubuque Line. A more careful analysis of their expenses has since been made covering operation from January 1st to September 1st of this year.

The following is a summary of this report in which you will note a portion of the traffic was train service with trail cars.

MINNEAPOLIS, ST. PAUL, ROCHESTER & DUBUQUE TRACTION CO. LINES.

EQUIPMENT:

Number of motor cars	8
Weight of motor cars	40 to 50 tons
Number of passenger trail cars	6
Weight of passenger trail cars	16 to 40 tons
Number of miscellaneous baggage, express and freight cars	26

PERFORMANCE FROM JAN. 1 TO AUG. 31, 1912:

Motor car miles	145,621
Trailer car miles (all classes)	51,276
Total car miles	196,897

DIRECT OPERATING EXPENSES FROM JAN. 1 TO AUG. 31, 1912.

	Cost per motor car mile	Cost per car mile
Wages of crews	$0.0568	$0.0421
Fuel (Engine naphtha at $.0966 per gal.)	.0763	.0564
OTHER EXPENSES:		
Gas engine oil	.0058	.0043
Supplies, oiling and heating cars	.0072	.0054
Maintenance of electric equipment	.0083	.0062
Maintenance of cars (all classes)	.0073	.0054
Car barn, shop and storeroom expenses and heating cars when in car barn	.0161	.0120
Total Direct Operating Expenses	$0.1781	$0.1318

The above statement of direct operating expenses does not include any superintendence or proportional charges, but does include all the direct expenses of maintaining and operating all the above equipment. It also includes all general overhauling charges incurred by the equipment as well as the running maintenance and expenses.

Depreciation of self-propelled equipments may well be a matter of opinion. It seems fair to assume as a minimum, that the life of the car body, trucks and electrical equipment may be taken as fifteen years and that of the engine as ten years. On this as a basis and making no allowance for salvage value at the end of this period, the depreciation of the car as a whole amounts of about $1,300 annually. As there is no way of determining the period at which the complete car would become obsolete, these figures are mentioned simply as an estimate, in view of the interest exhibited as to the probable life of engine-driven equipments.

The self-propelled car either as an independent unit or a semi-locomotive hauling trailers, must unquestionably be recognized as a method of transportation as well suited to some conditions as the trolley car and steam locomotive to others. In evidence of this is the interest shown to-day in the presentation of this paper.

PRESIDENT ACKERMAN:— I will ask Mr. N. W. Storrer, of the Westinghouse Electric and Manufacturing Co., to discuss this subject.

MR. STORER:— Like Mr. Potter, I wish to congratulate the Committee on the most excellent report they have made, and also the Association on having such a Committee. It is certainly a very excellent presentation of the subject, and is far superior to anything that has heretofore been made. The same Committee should be continued for another year in order to complete the work.

The history, as given here, is interesting, but the part that is really most interesting to me is the location of the line between self-propelled cars and trolley cars. The Committee gives a fair statement in regard to that, and Mr. Potter has added some interesting comment, but I cannot let the report stand without criticism of the comparisons made between trolley cars and storage battery cars which were taken from other reports. These look simply ridiculous. One seems to me to be faulty in almost every respect. At first sight of the estimated weights of the two cars, one is inclined to believe that the storage battery has a balloon effect on the car, but an examination of the details shows that this is not the case. The weight of car for the trolley line is evidently based on using the smallest size of standard railway equipment at present in regular service, but it must be self evident that the motor and control equipment for two cars of the same seating capacity, and for the same service, should have practically the same weight when the only difference is due to a small difference in voltage. Instead of having the motor and control equipment of the trolley car weighing 2½ times as much as for the trolley car, it should not weigh more than 10 per cent. or 20 per cent., and considering that the battery weight is 2400 lb., which has nothing in the trolley car to off-set it, I should say that the weight of the trolley car would be about 15,000 lb., instead of 18,875 lb. as given in report. That would certainly be enough if the weight of battery car were only 17,275 lb. This would reduce the power consumption of the trolley car by about 20 per cent.

The cost of trolley line is also excessive. One 0000 wire should be ample for such light service, and the cost of line construction should accordingly be reduced $500 or $600 per mile.

The power station equipment for the trolley line is estimated as 50 per cent. heavier than for the battery line, in spite of the fact that the latter is estimated to require 43 per cent. more kw-hours. The same equipment would do for either, unless enough cars were provided for the battery equipment to give practically 100 per cent. load factor. Even then, the load factor for the trolley line would not have to be much above 50 per cent. to equal it.

If these discrepancies were removed, the trolley system would be far ahead of the battery system. In fact, I cannot see how the battery could even be a competitor of the trolley for such a line, if cost alone governed.

Please do not understand from my remarks here that I am opposed to the use of battery, gasoline-electric, or gasoline cars of any kind. I am very much in favor of them for any service for which they are fitted; but there is no use in exploiting new things by making false assumptions. It does not pay to deceive ourselves; so that, whether comparisons are made either for home consumption or for foreign shipments, they should be absolutely fair and above board.

The storage battery is something for which the world has long been waiting — for 25 years at least, in railway work — and no one will be happier than I to see it. Judging from the data given in the paper, however, neither the lead plate type nor the Edison type is ideal. The data given are presumably fair to both types; if not, we shall probably hear it corrected. It seems to me that, if we could get Mr. Burbank to cross the Edison with the lead battery, so as to produce a new one having the good qualities of both, we should certainly approach the ideal. A battery with the high efficiency and good regulation of the lead plate type, combined with the low maintenance cost and light weight of the Edison, would be a winner. Either type at present is remakable in its way, and represents great improvements over the battery of a few years ago, but either one by itself is a little weak for heavy railway work.

In spite of their inherent weaknesses, however, there will undoubtedly be a good many storage battery cars used where trolley is not permitted, as in New York and Washington, and for short lines where service is so infrequent as to make the cost of the trolley too great. If we had a really ideal battery, the gasoline motor could not compete with it for city trucks and automobiles, and it would have a good field in railway work. I therefore would favor holding out every inducement to assist in the production of such a battery.

MR. DRAKE:— I am only able to present deductions and experiences gained with the gasoline-electric self-propelled car in Europe. It may interest this meeting to have a few words from across the water, where we have carefully observed all efforts in the development of the self-propelled car with battery power, gasoline direct, or gasoline-electric. The records give us credit in Europe, with having had the most extensive experience in actual train miles with self-propelled cars. These experiences vary as much as do the countries and the languages. Our own experience — I am speaking for the moment in behalf of the French Westinghouse Company, (although I am no longer associated with them) covers the introduction, since 1905 of the self-propelled car in eight countries, with applications varying from tramway service to express lines. The most notable case of self-propelled, independent gasoline-electric cars in the world to-day exists in Hungary. It appears rather strange that a country so little developed in point of industry should have become the pioneer in the complete exploitation of passenger service on a steam railroad. This, however, is true and the Arad-Csanad road has a total record of over five million motor car miles. These records consist of details covering the cost of every item entering into the exploitation of these cars, from the platform expenses through to the amortization and have been presented in the report of your able Committee. The details are essential for examination and comparison.

One point which I might distinctly make, and I think it well to make it at this time, is that traction engineers are entering a situation where the proper economic presentation of

the self-propelled unit to existing roads is the most important work which they have before them. I discard for the moment new projects where a self-propelled car might serve until the traffic is developed to a point for either electrification or for some other means of transportation. It will be well consequently to examine each case as suggested by Mr. Potter. They are so distinct in character that one need not impinge upon the other. A situation which can be met most successfully by the storage battery cannot be fully met by either of the other two types of cars. I disregard for the moment the steam car or the compressed air, because the experience, which has been very wide and complete in Europe, shows that in point of maintenance, comfort of passengers and satisfaction of the public, they have had their day and have passed.

We have before us some very interesting results, and the experience in these various countries leads us to assume that the best economy must be arrived at with light cars and equipment. We have no central station back of us to help the independent unit over the peaks. We must adapt ourselves to the conditions and refine our material engines and apparatus to the point where we can maintain over a large system and a great variety of service on a basis which railway managers and traction engineers will find attractive.

I shall refer again to the Arad trains which run through an open country much like the Illinois prairies. They have changed since adopting this type of traction, a line which was losing money rapidly on passenger service, to an annual profit of over $200,000, and at the same time increased their train service nearly four-fold. Simultaneously with this increase of service, fares have been reduced one-third. I believe that until we can supply, especially the steam railway managers, for their branch lines and for their local runs, material which will answer the purpose successfully, giving the comfort, lightness and attractiveness of electric trolley service, that we will not arrive at the proper point.

In reference to the 5,000,000 car miles on the Arad lines, the average cost of maintenance has been between 2.5 and 3 cents per car mile. I wish to point out, however, that in the

early days, or the years 1905, 1906, and 1907, we were largely gaining experience, and the motors which were chosen for the axles were too low in capacity and had more burn-outs — I speak quite plainly — more burn-outs than would be justified in any traction system of to-day, but those expenses have been totally absorbed in the cost records for those years.

MR. DODD:— I can only echo the words of some of my predecessors in regard to the character of this paper, and in particular the fifteen pages of bibliography, which appeals to me. To those who have had to do with collecting data on self-propelled cars, it is very valuable as an addition to the library, when looking up such questions.

There are a number of points worthy of discussion in this paper. I wish to call your attention to one point in particular. You will note in the history of the gasoline-electric cars as developed in this report, the earliest types of cars in almost every case had a storage battery auxiliary, and while the storage battery auxiliary is not used to such an extent to-day, there is an insistent demand, or rather suggestion that it would be advisable in connection with gas-electric cars, to put on the storage battery auxiliary. What I want to point out is the fact, that that idea of using the storage battery in connection with the self-propelled car, is based on a misconception of the real meaning and advantage of the electric drive and is based on ideas which are derived from constant potential control. To illustrate — with a self-propelled car having an independent gas-electric drive, if we were forced to keep constant voltage on the generator, and having constant horsepower from the engine were forced to maintain a constant current output, it would be absolutely necessary to furnish a storage battery auxiliary in order to furnish increased current when starting and in order to absorb reserve horsepower when running under light conditions. But these are not the conditions which we have with the electric drive as developed to-day. We are not limited to a fixed current from the generator, for the electric generator has the same overload capacity in current as the driving motors. The only fundamental limitation is the horsepower of the engine and by varying the generator voltage, it

is possible to obtain the full engine horsepower through the whole range of operation from slow speed and high tractive effort at starting up, to high speed and low tractive effort at full speed running conditions. Keeping this in mind, it is evident that with the variable voltage control, it is possible to obtain the same results from the gas-electric drive alone that would be obtained from the constant potential control with the additional storage battery. In addition to this, a storage battery would have an efficiency as pointed out in the report of only 40 to 60 per cent. and this battery loss is entirely eliminated by leaving it out. As far as weight is concerned the same weight of material which would give a kilowatt of continuous capacity in the form of gas engine and generator would only give a kilowatt for one hour if installed in the form of a storage battery. Without wishing to say anything against the storage battery car, I will say that whatever the development of the storage battery itself, there is to my mind no prospect of a time coming when the storage battery will be used as an auxilliary to the gas-electric drive, because with variable voltage control, the gas-electric drive gives the same results as the storage battery auxiliary and with greater economy in weight and power.

Mr. Beach:—I want to thank the Committee, and no doubt you all do, for the exellent report they have made and which is probably the first report that has been given on this subject. There are one or two points I want to speak about in regard to storage battery. On page 698 the efficiency of the Edison battery is given as 40.8 per cent. The fact is, that the actual efficiency of the Edison battery on a single normal charge and complete discharge is 61 per cent. and that is the lowest possible efficiency of the battery. In practice, where the batteries are charged at a high rate for a short period of time (we frequently charge as high as ten times the normal rate), you will find the efficiency considerably greater. We have observed efficiency as high as 75 per cent. There is a car equipped with these batteries running on the Pennsylvania Railroad, between Montandon and Mefflingburg, Pa., and that car has traveled over 75,000 miles. About six months ago a very exhaustive report was made by the engineer to the Penn-

sylvania Railroad, which showed the actual watt-hour efficiency of the battery as 66.7 per cent.; that is, the actual efficiency obtained in practice from an old battery. I will tell you a little about this kind of car, and what is true of this car is practically true of all our cars. The car weighs 32,000 pounds, has four G. E. 5-hp. motors, normal rating, a scheduled speed of 25 miles an hour, carries 4,000 lb. of batteries and travels 130 miles every day. There has never been any difficulty with the motors or batteries in any respect. It has never failed to make its schedule, even during last winter when there was very cold weather, the lowest temperature recorded being 40 deg. Fahr. below zero. The car stood out doors, had no barn, and with that low temperature no deleterious effects on the battery were observed whatever. The car always made its trips. Just a word about the weight of these cars. When the work of developing a car that could be driven with a storage battery was first started it was obvious that power must be conserved as much as possible as all the available power was in the battery. The cars were made as light as possible, as is shown in these reports. And to eliminate the friction losses in the car, the wheels were made to rotate independently of one another, but it is very difficult to say the exact amount. The lowest watt-hour consumption per ton mile that we have ever obtained was on a run between West Orange and Atlantic City. This car was built for the Chesapeake and Ohio Railroad and traveled on a single charge of battery from West Orange to Atlantic City, via Camden, a distance of 178 miles. The actual average running time was 31 miles an hour, and the actual power output of the battery, during that run was 32 watt-hours per ton mile. We think the result obtained was principally due to the fact that the wheels rotated independently. Time has not yet elapsed to accumulate sufficient data to very clearly demonstrate all the features of that peculiar type of drive, but with all the cars that have been built, probably 100, the highest watt-hour output that has been observed is 81 and the lowest 29.5 watt-hours per ton mile, the average of all the various types of cars in regular service being 50.2 watt-hours per ton mile.

In regard to the battery, a great deal has been published and it is probably not out of place to say there are many things that we do not know about. We do not know its life but do know that at the expiration of seven years (that being the life of the oldest battery) of constant use, there is no deterioration whatever; by that I mean there is no loss of capacity whatever. It is hard to say when this battery will begin to show deterioration. At present, all that is known is that at the expiration of seven years, it is impossible to observe any atomic change in either the iron oxide or the nickel hydrate — absolutely none. About its weight; an Edison battery will develop about 19 watts per pound of battery, while the best lead battery, when new, will deliver about 9 watts per pound of battery. The Edison battery improves during about the first three months of use and gains about 10 per cent. We know that it remains at that point for seven years, and, therefore, feel like saying that the battery is really a rugged, substantial, durable and practical thing. A very excellent feature of it is that it cannot be injured by any electrical trouble. The battery may be overcharged indefinitely without any injury whatever, or may be left completely discharged indefinitely without any injury. It can be undercharged, overcharged, left alone, or practically any way you want, with no resulting injury whatever. The application of this battery is, of course, as yet largely in the experimental stage, as far as traction work is concerned, but I think something has been done. As I said, there are about 100 cars in service, and all in very satisfactory shape. Three towns are served exclusively by these cars and I am glad to say that the companies are paying a dividend. We have been accused of being freakish in our design and that the cars are particularly light. They are light, but not much lighter than other cars, especially of recent design, the principal feature that permits the low energy consumption being the free wheel.

Mr. Milton:—The report of the Committee on Equipment, Appendix A, covering the subject of self-propelled cars embraces a large amount of very interesting and valuable data on this question, brought together from many sources

in a manner that shows evidence of a great deal of study and the devotion of much time to the subject. There are, however, some points in connection with the data given on storage battery cars to which I desire to call attention.

On page 695 the authors refer to trouble from fumes in the older storage battery car installations. This difficulty has been entirely obviated in the modern types of cars equipped with the lead battery, and it may be stated positively that in the operation of the cars on the Third Avenue lines of New York City there has been at no time any odor perceptible to the passengers or public. On the same page the authors refer to a performance of 8,000 miles by one of the batteries on the Englewood system. While this was a good record for the batteries manufactured at that time, it is interesting to compare this figure with the results now being obtained. Under conditions by no means favorable to maximum mileage life, a record of 26,000 miles without battery renewals has been made by a Hycap-Exide battery in the service of the Third Avenue Railroad; this being the only battery of the Hycap-Exide type requiring renewal up to the present time.

On page 697 the authors refer to the invention of the Edison cell as a milestone in the progress of the battery car. This language seems hardly warranted in view of the facts. If I am correctly informed, the lead battery, which has achieved so signal a success on the Third Avenue lines, was not adopted until after a series of exhaustive, parallel tests had been made on experimental equipments with both types of cell. I believe that this is the only instance in which such comparative tests have been made in an intelligent and exhaustive manner. Between the two types of cell, under the same conditions, in this class of service, and it would seem that the conclusion reached by the engineers of the Third Avenue Railroad Company ought to carry considerable weight.

I must take issue with the statements contained in one paragraph on page 697. Take for example the statement, "The maintenance of the Edison battery, assuming a life of seven years, is, however, only 0.5 cent per car mile com-

pared with the parallel charge of 3 to 4 cents per car mile for the lead battery." It is evident that the figures in reference to the Edison battery are based on an arbitrary assumption, since the first experiments with this battery in storage battery cars were made only about two years ago; and cars equipped with batteries of this type have been in *actual commercial service* not much over a year. It seems almost ridiculous to arrive at an assumption of seven years life from so short a period of actual operation. Furthermore the makers guarantee their batteries for only four years and it has yet to be demonstrated that this guarantee will continue to be made on a commercial scale.

In order to arrive at the figure of one-half cent per car mile, it is necessary to assume not only a life of seven years but a daily performance of over 150 miles per car, in order to accumulate in this period of time a sufficient sum on account of maintenance to pay for the renewal of a battery at half price. The figure of three to four cents per car mile for the lead battery is a conservative figure, not necessarily the best, that can be expected under favorable circumstances; it is based on actual operating conditions on the assumption of a daily mileage of about sixty per car. If this mileage were assumed in the case of the Edison battery it would require over 18 years at one-half cent per car mile to accumulate an amount sufficient to make one renewal at half price. Moreover the lead battery maintenance figure of three to four cents is not only conservative and based on a low daily mileage, but it is also based on the use of a lead battery equipment having a commercial mileage ability on a single charge far in excess of that which can be obtained from the Edison battery equipments with which the comparison is made.

It is very important to distinguish between the capacity available for commercial service and the nominal rated capacity of a battery. Commercial capacity is that which can be obtained with a voltage sufficiently high to give satisfactory speed and maintain a desired schedule. With the lead battery the entire rated capacity can be utilized com-

mercially. This is not true of the Edison battery, and it will be seen by reference to Table II that in none of the cases cited is a mileage of more than forty obtained on a single charge from batteries which are rated at 80 miles. We are credibly informed that this figure of 40 miles which is given in one case in this table is not actually obtained but that this battery is given a boosting charge after every 20 miles of operation and in the winter months this boosting charge must be given after every 10 miles; and that a special feeder has been run the entire length of the line in order to permit giving a boosting charge at the far end. I have before me a schedule showing the operation of this particular road during the month of March of this year, and note that after each round trip of 19.2 miles, occupying about one hour, a layover of one hour is provided, during all of which time the battery receives a boosting charge. In other words the total time occupied in boosting the battery is equal to the running time. This daily schedule shows a total of 115.2 miles, except on Wednesdays and Saturdays, when seven round trips are made, totaling 134.4 miles. The figure of 182 miles per day given in the table would, therefore, appear to be erroneous.

Also on page 697 the authors state — "Experience with electric trucks indicates a maintenance cost of 0.31 cents per truck mile for Edison batteries and 4.12 cents per truck mile for lead batteries." A statement of this kind appears to be entirely out of place in a report of this nature where no basis for the figures is given, nor the source from which they are derived. These figures appear to be repeated on page 724 of the report, and here reference is made to records kept by the Commonwealth Edison Co. of Chicago. If this refers to the records published in *The Automobile* of April 11, 1912, it is evident that some mistake has been made in copying the data. These figures show a battery maintenance cost for a period of twelve months amounting to 0.3 cents per mile for the Edison battery and 0.1 cent per mile for the lead battery. The same tables give figures covering the total mileage made by the batteries subsequent to their in-

stallation for which the battery maintenance per mile is 0.5 cents for the lead battery and 0.8 cents for the Edison battery.

In this connection I have the following letter from the Commonwealth Edison Company:

October 9, 1912.

"Mr. G. H. Atkin,
Electric Storage Battery Co.,
140 So. Dearborn St.,
Chicago.

Dear Sir.—Answering your inquiry regarding the statement on page No. 724, in the report of the Committee on Equipment of the American Electric Railway Engineering Association, I wish to say that all the records and costs regarding the electric trucks of the Commonwealth Edison Company are kept by the Statistical Department, and I know that this department, of which I have charge, has not given out any figures from which such a statement as referred to above could be derived.

Further the statement as given is materially incorrect, and of course does not take into consideration the cost of the batteries.

Yours truly,
E. J. Fowler,
Statistician."

There seems to be some error in the basis on which the watt hour efficiencies given in the middle of page 698 were determined. The figure of 37.7 per cent. is evidently derived from the actual figures given in Table II without any assumption as to loss in the charging system. The figure of 44.3 per cent. efficiency for the battery itself is evidently derived by making the assumption of 15 per cent. loss in the charging system. In other words, the figure of 37.7 per cent. is actual and the figure of 44.3 per cent. is based on assumption.

The figure of 72.7 per cent. voltage efficiency given for the lead battery in the table on page 698 is entirely too low and should be more nearly 85 per cent.

The entire reference to the operation of the Ephrata and Lebanon Street Railway, beginning on page 698, is so inconsistent and contradictory that it is evident that some serious

error has been made in compiling the data. This road is actually only 6½ miles long instead of 22. The statement that the car makes 22 trips a day, each 22 miles in length, or a total performance of 484 miles per day is obviously impossible. Furthermore, this car was not put into service until the Spring of this year and, therefore, has not been working in heavy snow at a temperature of 20 deg. Fahr. below zero as stated.

The figure of 1.5 kw. for operating the double truck car on the level, as given on page 699, is obviously a typographical error.

Referring to the paragraph on page 719, where records of car performances are set forth, I desire to state that these records were taken from cars on which the Hycap-Exide battery was installed and not on the cars equipped with the Gould cells, as would appear from the text.

The statement referring to energy consumption measured on the d. c. circuit, near the end of the same paragraph, appears to be erroneous, as it is the energy taken from the a. c. circuit that is evidently referred to.

The statement on page 720 that the batteries are maintained at 75 per cent. of their rated output is rather misleading. As a matter of fact the average capacity of these batteries is considerably greater than their rated output, and the figure of 75 per cent. is the minimum below which they are not permitted to fall.

Beginning on page 723 abstracts are quoted from a report of a Consulting Engineer. As these abstracts do not cite the source from which the information was obtained, it is difficult to criticise them in a satisfactory manner, but they contain a number of erroneous statements. On page 724 the statement is made that 30 per cent. more current is used in charging the Edison batteries than the lead batteries and from this the deduction is made that the cost of power will be 30 per cent. more than in the former case. No account, however, is taken of the difference in voltage efficiency. The comparison between the cost of maintaining lead batteries and those of the Edison type on page 724 have already been

discussed. Inasmuch as the financial results arrived at are based upon the data which is obviously incorrect and no attempt is made to substantiate these data, the results themselves can hardly be given serious consideration.

At the end of the third paragraph on page 727, the word "down" should be "on," so that the sentence will read, "would handle a 20-ft. trailer on short runs and on grades not exceeding 3 per cent."

In general, the results obtained within the last two years from storage battery car operation indicate that this type of self-propelled car will be an important factor in the solution of certain classes of transportation problems. It seems, however, a serious mistake to incorporate in a report of this kind figures and data which have not been substantiated, and cannot be substantiated by actual commercial experience for some years to come.

I would further like to ask a few questions. I was particularly interested in what Messrs. Potter and Storer said. I certainly agree with them, that we should not rush into the self-propelled car without careful examination in each case. Whether it is the storage battery car or the gasoline car, I do not believe that any of us believe in the "Doom of the Trolley" that we see advertised so much. There are legitimate and economical cases on record of storage battery cars. I believe to-day there are some storage battery cars and some gasoline cars operating where they should not be operating, and they simply hurt the game. Mr. Storer referred to the "balloon effect" of the storage battery. There is one type of battery which, if properly sealed, inasmuch as it gases continuously during discharge and charge, would probably have considerable "balloon effect."

Referring to the "Burbank Cross" mentioned by Mr. Storer, we have put out the new "Ironclad-Exide" battery which will bring about results according to some of Mr. Storer's suggestions without a "cross."

I would like to ask Mr. Beach a question. In some of his figures he stated the Edison battery had 61 per cent. efficiency. I would like to know if that is watt-hour efficiency

or ampere-hour efficiency? I noticed that he stated the Edison battery improved with age. All batteries increase in capacity up to a certain point. In fact, if a curve is plotted with battery capacity as ordinates and life as abscissae, you will notice the capacity will increase to a maximum point and then gradually falls down. In most cases of lead battery renewals, they are usually renewed when they get back to the catalog capacity.

As to there being an advantage in indefinitely overcharging a battery, I cannot see it, because it costs money. Whereas it may not hurt the Edison battery to overcharge it indefinitely, it is also true that with the Edison battery, it is usually necessary in practice to overcharge it, because there is no characteristic by which it is possible to exactly determine when the battery is fully charged. Also I do not see any reason for leaving a battery discharged.

PRESIDENT ACKERMAN:— I will now call upon some of the railway operating engineers, who have had experience in the operation of self-propelled cars, to continue the discussion.

MR. HAZELTON:— While I did not come prepared to discuss the question of self-propelled cars, I would like to say a word in commendation of the work that has been done within the last few years by storage battery experts toward lightening the cars. The older battery cars used to be altogether too heavy, and by lightening the cars it has been possible to make the battery a commercial success.

Reference has been made to the Englewood and Chicago storage battery line of some sixteen years ago, and as I happened to be the engineer for that line, a word or two may not be amiss. Battery cars were run for perhaps three years, but they never were a commercial success. There was no good reason why battery cars should have been applied to that road for the cars were too heavy to operate satisfactorily. When there was a change in the weather and the mud on the rails froze, or when there was a fall of snow the cars couldn't get back to the car house. The recent development in storage battery cars has changed that sort of thing, and under certain conditions battery cars are operated to advan-

tage for it is possible to carry people in cars that are a great deal lighter than was formerly thought necessary. There are many cases where a speed of 8 to 10 miles per hour is sufficient and for such cases small motors are satisfactory. By reducing the weight of the cars and equipment and by using roller bearings it has been possible to make a success of battery cars on certain lines where high speed is not required.

Another thing I would like to say in reference to self-propelled cars is in regard to the gasoline-electric car. I have had occasion, in connection with a newly-built road, to use a gasoline-electric car for the purpose of a work car, and for this purpose it has been an admirable device. I mention this as it is something that is somewhat novel. The car is provided with an electrically operated crane, and is used for carrying and distributing material. The electrically operated crane also has an elevating platform for the purpose of enabling the repair men to work on the trolley wire. The work car is used largely in place of a locomotive for switching cars, and for that purpose it is very useful. The car will pull almost any load put behind it, and I believe there are many purposes where it is worth while considering the gasoline-electric car for construction and repair service.

MR. HOLST:—Your subcommittee, in preparing this report aimed to gather together a historic brief of developments to date, for which we collected data from various publications and, for the more recent developments, direct from the manufacturers, and as stated in the report, no attempt was made to reduce the different types to a common basis or to check up the various figures. Therefore we wish to compliment Mr. Milton for taking the trouble to carefully check and suggest corrections and bring out some comparisons. The points of most value, however, are found lacking in print, namely, operating costs, amortization and comparison of service conditions. The report therefore recommends continuance.

MR. MILTON:— I would like to say that my discussion was not made in any spirit of criticising the Committee. I

know the difficulties in gathering together such data, especially on a new subject; but I could not allow the figures to pass without correcting them, and I obtained data from all the roads I could. I want to compliment the Committee as it obtained some very good information.

PRESIDENT ACKERMAN:— Gentlemen, what disposition will you make of the report? It is the recommendation of the Committee that the subject be continued.

MR. BENEDICT:— I would like to move a vote of thanks to this subcommittee for its very excellent report, with special thanks to the chairman.

(Motion duly seconded, stated and carried unanimously.)

MR. BENEDICT:— I also move that the report of the subcommittee be accepted and that its recommendation for continuance be followed.

(Motion duly seconded, stated and carried.)

MR. KELSAY:— This is an excellent paper and one to which I believe great heed should be given; and I would like to make a motion that the Committee take up in its next year's work, the subject of verifying the data relative to storage battery cars, so that the data cannot be questioned by any makers of storage batteries.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— We will pass now to the next subject, that of Squealing of Steel Wheels. I will call upon Mr. Adams to discuss that part of the report.

MR. ADAMS:— I have been very much interested in the report of the Committee in reference to this particular question, especially in noting the fact that it shows positions at which it had suggested the location of inserts. On page 670 is shown a section with an insert in the center of the tread, as well as at the throat of the flange.

I have made investigations of this character, particularly with lead inserts set in the face of the shoe, but did not accomplish the desired result, but did so when the lubricating inserts were placed in the flangeway. An insert set in on an angle may accomplish the result, but it strikes me that the lubricating medium should be placed in such a way as to

lubricate the flange throughout the life of the shoe. The angle at which this insert is set would make it work away from the flangeway as the shoe becomes worn.

In the study made of the subject I found that the cause of the trouble seemed to be in the vibration that was set up between the flange of the wheel and the head of the rail, and that any lubricating medium had to be located so as to lubricate that point, the point where the flange comes in contact with the head of the rail, in order to eliminate such vibration.

MR. SARGENT:— Some two years ago when Mr. Adams was in charge of the equipment of the Metropolitan Street Railway Co., of New York City, he asked me to see what I could do to stop the noise when brakes were applied, and I have been studying the matter ever since.

The noise which occurs when brakes are applied on an electric car results usually from two causes, acting together or independently.

First. Noise produced by the sliding of the brake shoe on the wheel. This occurs when there is oscillation of the springs or tilting of the truck, which causes the brake shoe to move relatively with the wheel, up or down, and then the sliding of the brake shoe on the wheel sets up vibration, resulting in noise. Any motion of the shoe with regard to the wheel when the brakes are applied always means a squeal or screech, whatever you may call it. It is increased in intensity as the grip of the shoe increases, insofar as all metal shoes are concerned. Very hard shoes because of their greater density and consequent resonance may squeal sooner and more frequently than softer shoes, because their grip on the wheel is more easily broken. Chattering of brakes comes under this head, which may be due to spring of the brake hangers in addition to the other causes above noted.

Second. The noise produced when brakes are applied (and when there is no vertical motion between the shoe and the wheel), from the grinding of the wheel flange against the side of the rail, in the same manner as the squeal during the passage of the car around the curve when brakes are not on, or in the case of new equipment with wheels that are very

close to the gauge of the track, . . flanges of which must crowd down, producing a grinding on the wheel flanges. This is the noise which is usually attributed to the sliding action of the brake shoe on the wheel. It, however, is distinct and usually continuous toward the end of the stop. Whereas the noise in the first case is intermittent and where there is tilting of the truck two squeals may result; one as the shoe is pulled up by the tilting of the truck, and the other when the truck frame returns to the horizontal position.

The wheels being rigid on the axle, it may happen that just when the brakes go on the wheel flange may be crowding the rail, tending to climb it. This may be due to the truck not being square, the wheels on the same axle being of different diameters or the track not being level — even though the stop be made on a straight track. The application of the brake destroys all side motion of the axle, prevents the wheels moving so as to bring the flanges in line with the rail and they must grind against the rail until the car stops or brakes are released, when the axles take their proper position.

I have observed the action of a great many types of electric railway cars operated in different kinds of service and in all kinds of weather. I find that the noise is not constant with the same pair of wheels, or for that matter in the same truck, but appears to vary with the position of the wheel with regard to the rail at the time of the stop.

When the rail is slightly moist, the noise is largely diminished, if not stopped entirely.

I stood beside a heavy electric car making a stop with the front pair of wheels locked. A loud squeal came from these wheels. As there was no movement of the wheels under the brake shoes it was evident that the vibration causing the squeal came from the contact of the wheel with the rail — and this gave me the idea that if we could stop the grinding between the wheel flange and the rail we would "kill" the squeal.

Up to that time we had been experimenting with hard and soft shoes, flanged and unflanged, on both steam and electric railway equipment, but had no success in stopping the noise.

With the idea in mind that the vibration producing the noise originated at the point of contact between the wheel flange and the rail, I had made up some brake shoes with composition filling in the flangeway of the shoe which wiped off the wheel flange, and at the same time slightly lubricated it. These shoes reduced the noise immediately. Experiments were then continued along this line until a special composition was developed which was unaffected by climatic conditions, remained in the shoe, did not diminish the grip of the shoe on the wheel and had good durability. It took a lot of study and experimenting to develop this particular composition, and the shoe which we are now turning out with the special filling in the flangeway practically eliminates the noise which has been termed "squealing." At the same time these shoes have reduced the flange wear of the wheel and the consequent rail wear, because it was very evident that in reducing the noise we reduced the vibration set up in the wheel by the grinding of the wheel flange against the rail. This grinding means wear — and wear means noise.

Referring to the report of your Committee, it defines the noise as the result of vibration set up in the wheel by the brake shoe friction.

I beg to differ from them as to the origin of the noise, believing that it results from the vertical slip of the wheel flange against the rail, producing vibration in the wheel.

I agree with their statement that the noise is common to both cast iron and steel wheels, reaching its maximum intensity with the rolled steel wheel. This is explained by the fact that the solid rolled steel wheel has greater resonance than the cast iron wheel, or the steel tired wheel, and also because, I believe, the friction between the steel wheel and the steel rail is greater than the friction between the cast iron wheel and steel rail.

Your Committee also states the screeching of brake shoes is not attributable to truck and track conditions.

I believe track conditions are largely responsible for the noise. I have heard the opinion expressed that a change in the rail section, tending to reduce the vertical sliding of the

wheel flange against the rail, will reduce the noise incident to the application of the brake. There is some evidence to support this, in the fact the noise is greatly reduced, if not eliminated, with badly worn rail and with wheels which have worn flanges. It also appears that the noise is less intense on the T-rail than it is on what is known as the Trilby rail.

Your Committee further states that lubrication between the shoe and the wheel reduces the noise. I agree with them in this statement, in so far as the lubrication contributes to reducing the grinding between the wheel flange and the rail. It has been clearly demonstrated in experiments that by the use of a special composition, filling in the flangeway of the brake shoe, the wheel flange becomes highly polished and smooth, the grit and roughness have been removed, enabling it to move against the rail with practically no grinding or abrasion, and hence no noise.

Mr. Adams:— I will ask one word more, Mr. President, on the point which Mr. Sargent brought out, and that is the possible effect of the shape of the rail head with reference to the wheel contour. It is quite apparent in studying the conditions that apply to new rail, especially of the girder rail type, that the bearing of the wheels on the new rail is comparatively small. In the study of the situation which I made I found that the greatest difficulty from squealing was experienced in the case of a newly laid rail.

The point which Mr. Sargent speaks of in reference to the possible change of the shape of the rail head is one which I think it might be well for our Association to take some notice of, and I think it would be well for the incoming Executive Committee to give consideration to this question, as one of the possible subjects for investigation. It appears to me that there may be merit in the suggestion that a change in rail head, which would give a larger bearing surface between the wheel and the rail head, would be a desirable condition to bring about. It might possibly eliminate some of this difficulty.

Mr. Brown:— In connection with Mr. Sargent's paper, in which he said the noise originated to a considerable extent

with the wear of the flange on the rail head, I will say that in the Sierra-Nevada mountains, the Southern Pacific Company were having considerable trouble with tires cutting the flanges. They tried a number of schemes of lubricating the flanges and rail heads, and finally adopted an oil wiping device. They also tried a sort of compressed graphite, which lubricated the flange of the wheel where it bore on the rail head. In addition to reducing the wear on the tires on all rolling stock very materially, this small amount of lubricant eliminated the noise almost wholly and that bears out Mr. Sargent's statement.

Mr. Phillips:— I do not wish to prolong the discussion on this matter, but in reply to the statement of Mr. Sargent, concerning the origin of the squealing or the noise of the wheels, I will say that in the experiments which the Committee made, the shoe was lubricated in various ways. We found that by putting the lubricating inserts in the middle of the tread of the shoe, that it did not entirely eliminate the squealing, but it did to some extent, tending to show that at least some small portion of the squealing is produced by the brake shoes. I will not attempt to say that none of the squealing comes from the flange of the wheel in contact with the rail head, but I am satisfied that I will be found correct in stating that, a good portion of the squealing is produced by the contact of the shoe on the tread of the wheel.

We also attempted in the test to place all the lubricant upon the flange of the wheel, and found that it did not eliminate all of the squealing, and that the best results were obtained by using the shoe illustrated on page 670. This was not only true in the experiments which I conducted, but it was also true in the experiments conducted by others in various parts of the country.

Mr. Adams' criticism of the angle at which the lubricating insert is put into the shoe, I believe, is a good point. You will understand that in the tests which we made we did not wear the shoes down to any considerable extent, because we did not have the time to do so, and it is quite likely that the lubricating insert will work away from the throat of the flange when the shoe becomes worn, and perhaps not elim-

inate the squealing. On the other hand, it will be found quite difficult to insert the lubricating medium in a straight line.

MR. ADAMS:— The facts I spoke of were from actual practice. We had two lines, operating about 175 cars each, and with shoes of this character the trouble was eliminated.

MR. MULLETT:— Up to the close of the year 1909 The Milwaukee Electric Railway and Light Co. had its full complement of cars equipped with chilled cast iron wheels, and during that time used shoes with solid metal across the entire throat and flange. Even under those conditions, where extremely hard metals were used face to face we had practically no trouble. However, as soon as we began to equip the cars with all steel wheels complaints came in from all parts of the city regarding squealing and especially from those parts where there were frequent stops.

Mr. Adams took up the question of inserting lead plugs in the brake shoes to obviate this squealing but in my opinion the squealing is due to the wheels. This matter of squealing of steel wheels was taken up with a representative of the Western Brake Shoe Co. and at present a shoe, with the hard metal left out of the flangeway is being experimented with: this is one with the so-called Diamond S insert. To my mind the question of graphite material in the flange is very important.

PRESIDENT ACKERMAN:— We will now take up the next subject of the report, which is Heat Treated Gears and Pinions. Is there any discussion on this subject?

MR. ADAMS:— If there is no discussion on this subject, I suggest that as the subject of Couplers for Interurban Cars, and End Connections for the same, have been approved by the Convention in the report of the Committee on Standards, that we pass to subject number seven, Specifications for Steel Wheels.

SECRETARY LITCHFIELD:— Even if the subject of Couplers for Interurban Cars and End Connections for the same, have been approved by the Committee on Standards, they also require the approval of this Convention. The matter is presented for adoption as Recommended Practice.

MR. ADAMS:—As I understand it, they were approved in the report of the Committee on Standards.

PRESIDENT ACKERMAN:— The action of the Committee on Standards was approved, but there was no approval of the report of this Committee.

MR. HANNA:— I move that the Specifications for Couplers for Interurban Cars where the Interchange of Equipment is Involved and the Specifications for the End Connections on Interurban Cars Engaged in the Interchange of Cars be adopted, as recommended by the Committee, namely, as **Recommended Practice.**

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— We will now pass to the next subject, which is Specifications for Axles, Shafts and Similar Parts. Is there any discussion?

MR. TIEMANN:— The chairman of the committee mentioned the fact that these specifications were discussed at a meeting of the Committee on Standards held in New York city, August 13–14, 1912, at which the various manufacturers were asked to be present and that a number of recommendations and suggestions were made. He also mentioned that the sulphur limit had been changed and also that Paragraph 11, "warped axles," has been allowed to stand and left to the discretion of the inspectors. The other points which were discussed then, so far as my company is concerned, remain the same, but if it is the desire to have the matter further discussed again, I would be glad to do so, but as the time is short, it may be preferable to have a written statement made and filed with the Secretary.

MR. SLOCUM:— With the revision as reported by Mr. Phillips, we are satisfied with the specifications and if it is the will of this Association to accept same, will do our part toward meeting it.

It is quite evident they are difficult requirements to meet, but we feel satisfied of our ability to fill them.

I will take this opportunity to thank this Association and the members of the subcommittee with whom we cooperated, for their efforts in securing suitable specifications.

MR. BROWN:— I move that the Specifications for Axles, Shafts and Similar parts be adopted as **Standard.**

MR. PHILLIPS:— Before we proceed with the vote on that

subject, I would like to suggest that we take up each of the specifications separately, that is, the Specifications for Cold Rolled Steel Axles and then the Specifications for Annealed Carbon Steel Axles, Shafts and Similar Parts, since they cover entirely different classes of material.

I am very glad to know that Mr. Slocum, who represents the Jones and Laughlin Company, is satisfied with the specifications drawn up by your Committee, with his assistance, and I should like very much to see these specifications adopted.

MR. BROWN:—I would amend my motion, and now move that we adopt as **Standard** the first, Specifications for Cold Rolled Steel Axles.

(Motion duly seconded, stated and carried.)

MR. HANNA:—I move that the specifications for Annealed Carbon Steel Axles, Shafts and Similar parts be adopted as **Standard.**

MR. TIEMANN:—As I suggested before, Mr. Chairman, what I have in mind would take some little time to discuss, and as the hour is getting late, I think you might prefer having the matter in the form of a written statement. It would be largely a repetition of what was said in New York. There are one or two slight discrepencies, and certain changes desired by a number of manufacturers, but I can file a statement covering those points.

WRITTEN STATEMENT FILED BY MR. H. P. TIEMANN, CARNEGIE STEEL CO.

In submitting this statement I wish to point out the fact that representatives of various steel manufacturers were present at the meetings of the Committee on Equipment and of the Committee on Standards by the direct request of the respective chairman. It is our understanding that the presence of our representatives was desired in order that they might assist in drawing up specifications which not only would insure material of suitable quality, as shown by composition, tests and methods of manufacture, but also would be acceptable alike to user and maker and which could therefore properly be termed "standard specifications."

We thoroughly appreciate the responsibility of the Association in providing the best possible specifications, and that nothing should be done which would be in any way inconsistent with this object. The adoption by the Association of a given specification does not, however, obligate any manufacturer (except with his consent), whether represented at any of the meetings of the committee or not, to accept it without question.

With both these ends in view we have called attention to certain points which left loopholes through which improper practice might creep in, and also to others which were considered impracticable according to the present state of the art, or which were unnecessarily severe on the Manufacturers while yielding no improvement in the quality of material. Certain of these features were of such a nature as to increase the cost of manufacture considerably beyond base price, and we have consistently taken the attitude, which is also that of the American Society for Testing Materials, that until the definite value or necessity of any requirement has been fully demonstrated it should not appear in standard specifications, as it can easily be embodied in any contract of sale if desired.

It has been repeatedly stated by members of the Committee on Equipment that these specifications were intended particularly for the small consumer who had not sufficient experience, or could not afford to employ any one competent to draw up specifications which would best fulfill his needs. Particularly in the case of this class, whose financial resources are extremely limited, it seems unreasonable to force him to pay an extra price in order to use such specifications. The remarks at the meeting about his waiving certain conditions contradict the expressed object mentioned above, as any one not competent to draw up specifications of his own would hardly be in a position to recognize what points were essential, and what were merely *considered* desirable.

Our opinions are based not only upon experience with Electric Railway Service, but even to a greater extent with

Steam Railroad Service, and the requirements of other classes of large consumers of steel.

In connection with the following criticisms I would call attention to the fact that nowhere is a modification or a change suggested which would permit of applying inferior material. In the majority of cases the criticisms have taken the form of pointing out contradictions or inconsistencies or of suggesting a wording which would make the specifications more definite, and hence more rigid, so that an inspector would know exactly what was required. As an example of an inconsistency, the case might be cited of the rejection limits for phosphorus in the axle specifications, which in one place is 0.04 per cent. and in another 0.05 per cent. One of the contradictions is the clause that all inspection and testing shall be at the manufacturer's expense, while immediately after it the statement is made that tests, other than at the manufacturer's works, shall be at the purchaser's expense. There are also a few typographical errors of no practical importance, but whose presence in a published form is not desirable. It might finally be mentioned that some of these changes, although agreed to almost from the beginning, have never been made.

Our various statements are practically the same which have been made at the different committee meetings and which are spread on the minutes.

We thoroughly agree with Mr. Aertsen's statement at the Committee meetings, that the adoption of the Specifications for Forged or Rolled Carbon Steel Wheels in its present shape, although only as working specifications until such time as the Committee on Equipment can effect its revision, is undesirable because it will carry such weight as emanating from the Association, that it will later be extremely difficult to make any changes, no matter how much it may then be realized that they are needed.

We understand that at the meeting of the Committee here in Chicago that the sulphur limit (section 3) of the Specifications for Annealed Axles has been raised to 0.05 per cent, and the cooling after annealing and hot straightening (sections 10 and 11) shall be in an "approved" manner.

SPECIFICATIONS FOR HEAT TREATED CARBON STEEL AXLES, SHAFTS AND SIMILAR PARTS

4. SAMPLES FOR CHEMICAL ANALYSIS.

It is desired that the limit for phosphorus given in section 3 be made 0.05 per cent. instead of 0.04 per cent. In the first paragraph of section 4 the phosphorus, as determined by the analysis of drillings taken half the distance from the center to the circumference, must not exceed 0.04 per cent. — the limit prescribed in section 3. In the next paragraph, however, it is stated that if additional analyses are made from turnings or borings taken from tensile test specimens the phosphorus may be 25 per cent. higher, i. e., up to 0.05 per cent. It seems unreasonable where samples for chemical analysis are taken from the same portion of the piece that in one case phosphorus must not be over 0.04 per cent. and in another case not over 0.05 per cent. In other words, if it is satisfactory in certain cases to have the phosphorus up to 0.05 per cent. it should be satisfactory in all cases.

It was formerly the practice in certain specifications of the American Society for Testing Materials (for example, the Specification for Structural Steel for Bridges, dated August 16, 1909) to give a maximum phosphorus limit as determined by ladle analysis and then state that on check analysis the phosphorus could be 25 per cent. higher. It was realized however that there might easily be cases where phosphorus would be, say 0.043 per cent. on ladle (the rejection limit being 0.04 per cent.) and upon check analysis would not exceed 0.05 per cent. Such material would consequently be rejected on ladle analysis, but would otherwise have been acceptable on check analysis; in other words, perfectly satisfactory material would be rejected. In the revised specification the A. S. T. M. now gives only the rejection limits on check analysis, permitting the manufacturer to use his judgment as to what ladle analysis is required to bring the material within the proper limits on check analysis. It would seem quite probable that the present section had been based on some such wording for the reason that in the Specifications for Cold Rolled Steel Axles at the top of page 773 it is

stated "In addition to the ladle analysis —" while as a matter of fact no ladle analysis is mentioned, as will be seen by consulting the first paragraph of section 4 on page 772.

With the rejection limit for phosphorus in section 3 made 0.05 per cent. the last clause in the second paragraph of section 4 should read "and the phosphorus in every specimen must not exceed the limit given in paragraph 3."

7. COLD BEND TEST.

In the revised specifications of the A. S. T. M. the ambiguity as to what is meant by Treating Plant heat was corrected. It might be explained briefly that the operation of heat treatment consists in taking the cold axles after forging, heating them in a furnace to a certain temperature, quenching them in some medium and then putting them back in a furnace and reheating to another temperature. The axles from the first furnace are termed the "quenching charge" and from the second furnace the "annealing charge." From this it will be readily appreciated that it would be possible in one annealing charge to have axles from different quenching charges, also from a number of different melts. In order to insure the proper number of tests it is suggested that the present wording of the A. S. T. M. be adopted, which is as follows: "One tension and one bend test shall be made from each annealing charge. If more than one quenching charge is represented in an annealing charge, one tension and one bed test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension and one bend test shall be made from each melt."

9. RETESTING.

The first word of the second line on page 770 of the report ("retesting") should be changed to "retreating."

10. HEAT TREATMENT.

Attention has several times been called to a desirable change in the wording of this section. At the end of the clause "shall then be reheated to the proper temperature" should be inserted the words "to refine the grain." The

clause "allowed to cool" (after quenching) is unnecessary, as quenching is understood to mean allowing a hot object to remain in a liquid until somewhere near the ordinary temperature. The reason for inserting the words "to refine the grain" is to insure having the steel heated for quenching past the critical point at which a change in structure is effected and the grain is refined, but not so far beyond this that the grain again becomes coarse. The final heating or annealing is not carried so far in the previous operation as it is simply for the purpose of removing any strains, and also of modifying to the desired point the physical properties resulting from the quenching.

11. HEAT TREATMENT.

This heading is evidently a typographical error and should be changed to "Warping" or "Warped Axles or Shafts."

13. FINISH.

In the second line of this section the wording "on surface finishing" should be changed to read "on the surface for finishing" in order that the meaning may be perfectly clear.

15. INSPECTION.

This section is the same as that originally adopted by the A. S. T. M. for the same specifications. On account of certain contradictions and discrepancies it has been reworded as follows, and it is suggested that this revision be submitted:

INSPECTION AND REJECTION.

(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the axles, shafts, or similar objects are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or

elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) All tests and inspections shall be so conducted as not to interfere unnecessarily with the operation of the works.

(d) Unless otherwise arranged, any rejection based on tests made in accordance with section 10 (b) shall be reported within five working days from the receipt of samples.

Samples tested in accordance with section 10 (b) which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

The third sentence of section 15 in the A. E. R. E. A. specifications reads "all tests and inspection shall be made at the place of manufacture prior to shipment and free of cost to the purchaser." This is contradictory to the fourth sentence which states that the purchaser may make tests in his own test room or elsewhere but at his own expense. The present wording could also be interpreted to mean that the cost on inspection by the customer's representative should be borne by the manufacturer which, of course, is not intended.

Attention might be called to the fact that the present revision of the specification of the American Society for Testing Materials for heat treated axles, shafts, and similar objects is much clearer than as originally drawn up.

WRITTEN STATEMENT FILED BY MR. G. AERTSEN, MIDVALE STEEL CO.

HEAT TREATED CARBON STEEL AXLES, SHAFTS AND SIMILAR PARTS

2. DISCARD.

Should not this be worded like the wheel specifications: "Freedom from injurious pipe and segregation?"

3. CHEMICAL COMPOSITION.

Has it not been the consensus of opinion of your Committees that the rejection limit for phosphorus and sulphur should be not less than 0.05 per cent., the table of limits showing this figure, and the provision for a check analysis .25 per cent. higher being omitted from section 4.

4. SAMPLES FOR CHEMICAL ANALYSIS.

See same section in criticism on Forged or Rolled Carbon Solid Steel Wheels, page 826. Even if this suggestion is approved, a check analysis might sometimes be desired for the purpose of identifying forging and test bars.

6. SPECIMEN FOR TENSILE TEST.

There has been discussion regarding confusion in describing and identifying different operations of melting, quenching and annealing. In order to avoid this, would it not be well to replace the words "open hearth heat" by the word "melt" and call the operation of heating and quenching a "quenching charge" and to call the operation of reheating for purpose of annealing "annealing charge."

If this is done, it would seem as though section 6 might read "test specimen shall be taken from the crop end of one axle, shaft, or similar part for each annealing charge. If more than one quenching charge is represented in an annealing charge, one test specimen shall be taken from each quenching charge. If more than one melt is represented in a quenching charge, one test specimen shall be taken from each melt."

7. COLD BEND TEST.

The same remarks apply as to section 6. As a mere matter of form, could not sections 6 and 7 be combined as has been done by the A. S. T. M. in specifications for Heat Treated Steel Axles, which are practically duplicates of the A. E. R. E. A.?

9. RETESTING.

Is there not a typographical error on the second line, page 770? It would seem that the first word should be "retreating" instead of "retesting."

10. HEAT TREATMENT.

There has been a discussion as to the best wording for this clause. May I suggest the following:

"The axles, shafts, or similar objects shall be allowed to become cold after forging; shall be reheated to the proper temperature to refine the grain (a group thus reheated being known as the "quenching charge"), and quenched in some medium; and then reheated to the proper temperature for annealing."

11. WARPED AXLES OR SHAFTS.

Is there not a typographical error in the section bearing this number on page 770, which should bear this title instead of "Heat Treatment?"

15. INSPECTION.

In place of this paragraph I take the liberty of suggesting the following from the A. S. T. M. specifications on the same material, which was the result of much argument and combined effort on the part of both manufacturers and consumers.

"The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the axles, shafts or similar objects are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

All tests and inspections shall be so conducted as not to interfere unnecessarily with the operation of the works.

Axles, shafts, or similar objects which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

Unless otherwise arranged, any rejection based on tests made in accordance with Section ( ) shall be reported within five working days from the receipt of samples.

Samples tested in accordance with Section ( ) which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time."

In this connection I am tempted to refer to a remark of Mr. Phillips in a discussion at the Convention which implied that the specifications were compromises between the manufacturer and consumer. Of the items on which the manufacturers were consulted, it would seem as though the compromises had consisted in your Committees listening to and disregarding what the manufacturers might have to say.

WRITTEN STATEMENT FILED BY H. P. TIEMANN OF CARNEGIE STEEL CO.

SPECIFICATIONS FOR ANNEALED CARBON STEEL AXLES, SHAFTS AND SIMILAR PARTS

3. CHEMICAL COMPOSITION.

It is suggested that the limits for manganese be changed to 0.40 to 0.80 per cent., the same as in the specifications for heat treated axles and for cold rolled axles. This subject was thoroughly discussed at the time the specification for heat treated axles was drawn up, and it was explained that the greater spread was on account of different practices by different manufacturers. We can see no reason why the annealed axle specifications should have closer limits than the specifications for heat treated axles, which represents a higher grade or class of material. The remarks on the phosphorus limit for heat treated axles also apply here.

5. TENSILE TEST.

In the specification for "Locomotive Materials — Annealed Steel Forgings," adopted June 1, 1912, by the A. S. T. M., which is for similar material, the yield point or elastic limit, as determined by the drop of the beam of the testing machine, must be at least half the tensile strength. As a result of one of the meetings of the Committee on Equipment the elastic limit was changed from 55 per cent. of the tensile strength to 44,000 minimum as shown in the present specifications. As stated at the time, however, this minimum elastic limit is high for the minimum ductility shown for annealed forgings, which are intermediate in grade between untreated forgings and heat treated forgings. The latter should be employed when an elastic limit higher than 40,000 is desired. It is suggested that the requirement as to elastic limit be changed to conform with that of the A. S. T. M. specification above.

7. COLD BEND TEST.

It was pointed out in the meeting of the Committee on Standards held in New York on August 13th, that in order to avoid all ambiguity, "annealed heat" should be changed to "annealing charge" and that "open hearth heat" should be changed to "melt." Furthermore, according to section 1 the

method of manufacture is not necessarily restricted to the open hearth process; consequently the term "open hearth heat" is not sufficiently broad.

10. ANNEALING.

As in the corresponding paragraph for heat treated axles, it is suggested that in the clause "shall then be reheated to the proper temperature for annealing" the words "for annealing" be omitted and the words "to refine the grain" be substituted. Unless the words "to refine the grain" are inserted it would not be compulsory to heat to the requisite temperature, in which case the grain could be of the same size as before heating (or even considerably greater), and the only advantage would be to remove any strains, whose presence however, in a carefully forged axle is doubtful, as proved by axles which successfully undergo the M. C. B. drop test. With these changes the section clearly indicates what is meant by "annealing."

15. INSPECTION.

The same remarks as for the similar paragraph in the specification for heat treated axles also apply.

WRITTEN STATEMENT FILED BY MR. G. AERTSEN, MIDVALE STEEL CO.

ANNEALED CARBON STEEL AXLES SHAFTS, AND SIMILAR PARTS

2. DISCARD.

Should not this be worded like the wheel specifications: "Freedom from injurious pipe and segregation?"

3. CHEMICAL COMPOSITION.

Why should not manganese limits be 0.40 to 0.80 per cent, the same as in Heat Treated Axles.

Recommend phosphorus and sulphur limits and rejection limit 0.05 per cent, the same as in Heat Treated Axles.

4. SAMPLES FOR CHEMICAL ANALYSIS.

See same section in criticism on Forged or Rolled Carbon Solid Steel Wheels, page 826. Even if this suggestion is approved, a check analysis might sometimes be desired for the purpose of identifying forging and test bars.

5. TENSILE TEST.

It is our opinion that the figure for the elastic limit taken by extensometer 44,000 per sq. in. is too high. Yield point of 40,000 per sq. in. is, in our opinion, as much as can be safely guaranteed under the treatment prescribed.

6. SPECIMEN FOR TENSILE TEST.

I suggest that the words "melt" and "annealing charge" be substituted for the words "open hearth heat" and "annealed heat."

7. COLD BEND TEST.

The same remarks apply as to wording. Objection is made to the introduction of cold bend test as described. If the yield point is substituted for the elastic limit described in section 5, the cold bend test is permissible, but should read "without fracture on the outside of the bent portion."

10. ANNEALING.

I understand that the last sentence will read "allowed to cool slowly in an approved manner."

15. INSPECTION.

Remarks on the same paragraph in specification for Heat Treated Axles may apply. (See page 815.)

MR. ADAMS:— These specifications which we are now considering, if approved by this Convention, will have to be submitted to the Committee on Standards for their approval before they are adopted.

PRESIDENT ACKERMAN:— Do I hear Mr. Hanna's motion seconded?

(Mr. Hanna's motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next subject for consideration is Specifications for Forged or Rolled Solid Carbon Steel Wheels for Electric Railway Service.

MR. ADAMS:— Mr. Chairman, in order to bring this question directly before the Convention, I desire to make a motion

that the Specifications for Forged or Rolled Solid Carbón Steel Wheels for Electric Railway Service be approved by this Association as a working specification, and that the Committee be instructed to continue its investigation relative to these specifications and with special reference to tapes, gauges and suitable facilities for making physical tests. Also that the Committee confer with the Committee on Way Matters relative to the contour of wheel and rail design.

MR. BROWN:— In considering this matter of steel wheels, in one part of the report it is mentioned as a specification for solid steel wheels, and then in the detail it says, "Rolled Steel Wheels." I think any committee in investigating this question should not only include the rolled steel wheels but cast steel wheels. We have under test on our lines a number of cast steel wheels which are giving excellent satisfaction and it is a matter worthy of consideration.

MR. COFFIN:— I would like to see this matter of tapes and gauges, for steel wheels worked out more fully. The M. C. B. standard tapes do not serve our purpose, the graduations are not fine enough, nor do they have range enough.

The question should also receive consideration, of whether the tape should be spaced from flange or from outside edge of rim.

MR. TIEMANN:— Very much the same remarks might be made as about the axle specifications, except, as I understand it, this is going into a working specification. The specifications for wheels had more time devoted to their discussion, than any other of the specifications, the discussions altogether extending over several days.

There are a good many points on which there was a radical difference of opinion between the manufacturers and the street railway people, and I should like the privilege of submitting a statement on this matter.

PRESIDENT ACKERMAN:— If there is no objection on the part of the Convention, the statement will be received and included in the proceedings. (No objection.)

WRITTEN STATEMENT FILED BY H. P. TIEMANN OF CARNEGIE STEEL CO.

SPECIFICATIONS FOR FORGED OR ROLLED SOLID CARBON STEEL WHEELS FOR ELECTRIC RAILWAY SERVICE

Attention has been called a number of times to the fact that the present specifications should cover only wheels for city service and that other specifications should be prepared for wheels for interurban service which corresponds closely to steam railroad service.

3. CHEMICAL COMPOSITION.

We would suggest making the lower limit for manganese 0.55 per cent. instead of 0.60 per cent. to conform with the similar specifications of the A. S. T. M.

4. SAMPLE FOR CHEMICAL ANALYSIS.

Conformity of the material to the chemical requirements given in section 3 should be determined by ladle analysis and if desired, check analysis should be made by the purchaser from drillings taken at any point in the plate or from two points, in the plate on radii at right angles to each other, these check analyses also to conform to the requirements of section 3. With the present state of knowledge as to what is essential to give the best results in service we think the above is all that is necessary to be specified in regard to composition and chemical analysis. The maximum variation of five points in carbon between two drillings from the same wheel is too close, and at least ten points should be allowed unless definite evidence is obtained and submitted that such variation impairs the quality or serviceability of the material. Our objection to the analysis of the two additional wheels, should the average of the first vary more than five points from the ladle analysis, is largely based on section 7 (r) Mating, and is as follows: A check analysis, as its name implies, is for the purpose of assuring the customer that the material is of the specified composition. If this point is agreed to, and the check analyses are performed by the customer or some outsider, great delay will be caused by the length of time required to obtain the results, particu-

larly where it is necessary to analyze additional wheels. This would mean a very great storage space at the Works since the wheels could not be mated and shipped until the matter was definitely settled. Even if the customer's representative made the analyses at the Works, considerable additional expense would result, which would naturally be reflected in the higher cost of the product.

The value of mating by carbon has not yet been demonstrated, and we would suppose that even if such were the case it would also be necessary to take into consideration the variations in the other elements, particularly manganese and silicon. When all the facts are known if may be found preferable to adopt some hardness test such as that furnished by the Scleroscope or the Brinell machine. Such experiments are now being made or are under consideration by certain of the large steam roads. Certain electric roads also are trying out wheels of higher carbon than permitted in these specifications with a view to determining whether they will give better service.

On account of the added cost we think it would be more desirable to omit such special features whose value is yet to be proved. If any customer is convinced that these features are of advantage, and he is willing to pay the added cost, it will be a simple matter to have them included in a contract, but for those users who are not convinced, particularly in the case of small roads, the added expense would seem an unnecessary burden.

It would also be possible for any customer to make check analyses and mate according to his own ideas, which at present is being done by one large user in some experiments, or perhaps best of all to mate by heat numbers (and, of course, tape sizes).

It might also be pointed out that on a very small proportion of the output of a given manufacturer it would be possible, without an excessively high extra cost, to furnish wheels according to special requirements, as these should be selected from the total number, but that it would be abso-

lutely out of the question to attempt to do this on all or even a moderate percentage as, on account of the great loss entailed, the price would be absolutely prohibitive.

This subject has been discussed at great length at all the meetings of the Committee at which any of the manufacturers were present.

5. ANALYSES FURNISHED.

In the last sentence of this section the words "complete record of each shipment" are not sufficiently clear, as was pointed out at the meeting held in New York, August 13th.

7. WORKMANSHIP.

At the meeting held in New York on August 13th, it was pointed out that in the case of machined wheels reference was made to "back of rim, contour and face of rim" (which we understand are collectively referred to as "contour" for electric railway service), while in the case of wheels with rolled finish, reference was made simply to "contour." It was our understanding that this would be corrected in order to avoid any misunderstanding, and that in both cases reference should be made either to "contour" or to "back of rim, contour and face of rim."

7. (d) THICKNESS OF RIM.

We would suggest not limiting the thickness of rim over that specified, but having it controlled by the maximum allowable weight.

7. (i) DIAMETER OF HUB.

A variation in diameter of $\frac{3}{8}$ in. over that specified is so close that machining will be required in the majority of cases. We should very much prefer having the variation over that specified limited by the prescribed maximum weight, or else increased to $\frac{5}{8}$ in.

As was pointed out at the meeting of the Committee on Standards, in New York on August 13th, no provision is

made to limit the eccentricity of outside of hub to tread. Without some such clause it would be possible, according to section 7 (i) to have greater eccentricity than would be acceptable for interurban service, as we know from experience. Specifications of the A. S. T. M. provide for this by limiting the variation in the thickness of the wall of the hub to ⅜ in. at any two points.

7. (k_2) PROJECTION OF BACK FACE OF HUB.

The limit of 1/32 in. either way we considered too small, but agreed to 1/32 in. over, with variation under changed to ⅛ in. This would seem to be reasonable as a variation of ⅛ in. either way has been and is agreed to without question by the largest and most up-to-date electric railways.

7. (o) ROTUNDITY.

It has been pointed out a number of times that a variation of 1/16 in. should be permitted for wheels with rolled finish, the same variation as is allowed in the next section covering "plane." It was our understanding each time that this was simply an oversight and would be corrected.

7. (r) MATING.

As already stated under section 4, we believe that mating by carbon should be made a matter of contract for such customers as deem it essential.

7 (s) WEIGHT.

We believe the maximum weight allowance should also be made a matter of contract, as, on account of the variety of sizes and designs at present in use, the specified percentages on many classes are altogether inadequate. In order to meet such close weight limits as those prescribed it would be necessary to furnish wheels conforming as closely as possible to minimum tape sizes and with minimum thickness of rim. This, it is needless to point out, would mean a minimum service. With, however, a fair percentage of overweight, it would be possible to furnish maxi-

mum tapes and thick rims which would yield a very much better mileage. From our own experience with customers who desired wheels as light as possible, but who yet did not overlook the great advantage to themselves in wheels capable of furnishing high mileage, we believe the following percentages would be about as low as practicable:

	Machined finish.	Rolled finish.
Wheels up to and including 34 in. in diameter.....	12 per cent.	14 per cent.
Wheels over 34 in. in diameter	11 per cent.	13 per cent.

9. BRANDING.

We believe the stamping of the letters "C," "T" and "Pr" should not be a part of this standard specification (in line with remarks on mating by carbon) but should be made a part of a contract when so desired. The marking according to specifications should be limited to manufacturer's brand, heat number, serial number of the wheel and mark indicating location of wheel in the ingot, all of which are to be stamped; tape sizes to be stenciled.

10. (e) INSPECTION.

It seems to us that ten working days is rather long to wait for a report of rejection of material based on tests at destination, as five days is all permitted by the specification of the A. S. T. M.

10. (g)

It seems to us that this section is sufficiently covered in the title.

10 (h)

This holds the manufacturer responsible for cracks or breaking irrespective of the treatment which the wheels may have received in service, and we believe this is sufficiently covered by the terms "defective material or workmanship." If, how-

ever, it is desired to leave these two terms in, they should be modified to read "—— cracks or breaking caused by defective material or workmanship."

Reference to patent litigation is not objectionable in any way, except that it would seem properly to belong in the contract.

Mr. Adams:— I desire to state clearly my position in this matter, and the position of the Committee on Standards, so far as I understand it. The Specifications for Forged or Rolled Solid Carbon Steel Wheels for Electric Railway Service were referred to the Committee on Standards and thoroughly discussed, due consideration being given to the points that were brought out by the manufacturers. The specifications did not receive at that time sufficient votes to have them approved by the Committee on Standards. The minority of the Committee on Standards, I believe, took the position that it would be better to have the specifications, in the present form, put into practice by the member companies, and have them tried out, which would enable the member companies and the manufacturers to know more about the specifications, before adopting them as a recommended practice, or a standard, and it is with that understanding that I make this motion. I make the motion, acting as the Vice-Chairman of the Committee on Standards.

I feel that it puts the specifications in desirable shape, so that we will know more about them in another year. It gives the manufacturer a chance to have wheels made according to these specifications, so that they can determine the essential points that are to be changed, if there are any.

Mr. Aertsen:— I would like to add to Mr. Tiemann's statement, one suggestion, and that is if these specifications are adopted as working specifications by this Convention, it will be, I think, very difficult to change the few points which make it, from the manufacturer's point of view very difficult, if not impossible, to carry the specifications into practical working effect. There are in it items which seem to us to properly belong to the contract. They are specifications which we might be able to fill for individual purchases, but as general specifications, covering all of the consumers, as well as the producers

of forged steel wheels, I can see, from my own company's point of view, that it is almost impossible to meet the specifications.

In answer to the suggestion that was made that cast steel wheels should be covered by these specifications as well as forged steel wheels, I do not think the tolerance and other provisions in the specifications will permit that. If it passes this Convention, and goes back to the Committee on Standards, there are some suggestions which can be made, which in my opinion, would make them more workable specifications than they are now.

WRITTEN STATEMENT FILED BY MR. G. AERTSEN, MIDVALE STEEL CO.

SPECIFICATIONS FOR FORGED OR ROLLED CARBON SOLID STEEL WHEELS FOR ELECTRIC RAILWAY SERVICE

TITLE.

According to my record, it was the consensus of opinion at the meeting of the Committee on Standards, held in New York, August 13, 1912, that these specifications should cover wheels for city service only and that other specifications would be prepared covering wheels for interurban service and service of like character.

1. PROCESS.

Is there any objection to making this paragraph read "steel for wheels shall be made by the open hearth *or other approved* process," thus making it like similar paragraph in your specifications for Heat Treated Axles, etc.?

3. CHEMICAL COMPOSITION.

At the meeting of the Committee on Standards, New York, August 13, 1912, the question of separate chemical specifications for acid and basic steels was discussed and apparently met with the approval of your Committee. Was this proposition ultimately settled adversely?

4. SAMPLES FOR CHEMICAL ANALYSIS.

Would it not be well to make part of the third line in this paragraph read "four holes *about* ½ in. diameter," instead

of "four ½ in. holes?" An ignorant and exacting inspector might make trouble under the latter reading.

As suggested in my letters of June 5, 1912, to Messrs. Holst and Benedict of your Committee, I suggest that the following sentence be inserted at the beginning of this section:

> "To determine whether the material conforms to the requirements as to chemical composition specified in section 3, an analysis shall be made from a test ingot taken during the pouring of each melt."

Without this, the last sentence of the last paragraph of the section is inconsistent as no "heat analysis" has been mentioned for which anything else can be substituted.

I cannot emphasize too strongly my objection to covering by a general specification such a provision as mating wheels in pairs according to their carbon content.

There is much to be said in favor of doing this extensively for the purpose of information, and the Midvale Steel Company, which I represent, has been for sometime co-operating with several of the large users of wheels in both steam and electric service in an effort to obtain results which will make possible an intelligent conclusion.

You will, I think, agree with me that such a conclusion can be reached only when conditions of service as well as conditions of manufacture are carefully observed and recorded.

Such a special provision as mating by carbon or by any other characteristic except size should, in my opinion, be covered by special contract or condition on a purchase order and is, in the present state of the art, out of place in a general specification.

5. ANALYSIS FURNISHED.

The words "a complete record of each shipment" are too comprehensive and indefinite, and literally interpreted might be claimed to cover much that is outside of the intention of a general specification. In any event, such a provision should appear in the contract — not in the specification.

7. WORKMANSHIP.

Reference by number to a drawing should appear in contract — not in specification. Rolled tolerances should govern on all wheels covered by an order permitting the manufacturer to furnish wheels in rolled condition, even if same are machined by the manufacturer for his own convenience.

This was, I believe, agreed upon at the meeting in Pittsburgh April 19, 1912, of the Committee on Equipment, and is referred to in my letters to Messrs. Holst and Benedict of June 5, 1912.

It is, in my opinion, important that this question should be settled in the beginning in order to avoid unpleasant discussions later on.

It seems a possible waste of time to discuss in detail the various tolerances enumerated in the present specification if it is intended that separate specifications shall be made for interurban and for city service, and in looking over the minutes of the Pittsburgh meeting of the Committee on Equipment April 19th and 20th, I can have no doubt that such was your intention.

In spite of this, and at the risk of unnecessary repetition, I will quote what I have said many times to members of your Committees and in my letter of June 5, 1912, to Messrs. Holst and Benedict.

7. (f) THICKNESS OF PLATE.

In my opinion, no guaranteed weight in the way of percentages or otherwise should appear in a specification which covers dimensions by maximum and minimum tolerances. Such a guarantee is quite permissible in individual contracts covering a special and definite size and type of wheel, but is out of place in a general specification.

7 (i) DIAMETER OF HUB.

As to diameters of hub, I think some leeway should be allowed permitting it to be less than that specified. Changes in length of hub often called for by users (particularly by roads using a small number of wheels and buying in small quantities) frequently involve corresponding variations in diameter which

cannot be avoided unless the manufacturer changes his whole equipment.

This will be more readily understood if it is borne in mind that the hub may be formed in a series of dies and if a leading die provides sufficient metal for a hub of definite diameter and length, an increase in the length obtained in a subsequent die will involve a corresponding decrease in diameter.

In this particular I agree with the remarks of Mr. Tiemann in his letter of the 16th instant addressed to Mr. Litchfield, and also agree with what he says regarding $7(k_2)$, Projection of Back Face of Hub.

7 (o) ROTUNDITY.

While a limit of 1/32-in. may be permissible for machined wheels, it is not enough for rolled wheels; 1/16-in. allowance appeared on the copy of the specifications which Mr. Holst showed me on June 3, 1912, and was also practically agreed upon at the meeting of the Committee on Standards in New York, August 13, 1912.

7 (r) MATING.

As indicated above, it is my opinion that a general specification should not govern mating except by sixes. While this may be permissible, or even desirable, in cases of special contracts with large users, it will evidently work a hardship upon the small consumer without any commensurate advantage. I say this because I have so far been unable to obtain any data which *proves* the value of the scheme to mate by carbon which may be said to be still in the experimental stage.

7 (s)

No weights should be guaranteed in specifications although they may be properly so guaranteed in contract.

9. BRANDING.

In my opinion any marking beyond that necessary for the identification of the wheel should be a part of a contract — not of a specification, and in any event there should be no provision for doing such additional marking *while the wheel is*

hot. A little consideration will convince you that such practice would slow up the process of manufacture without any resulting benefit.

10 (e) REPORT OF REJECTION.

Should be made in less than ten working days. Specifications showed me by Mr. Holst on June 3, 1912, mentioned two working days. At the meeting of the Committee on Standards in New York August 13, 1912, five working days was the time mentioned.

10 (g) ROLLED WHEELS.

May not this interpretation be omitted, as it is covered by title?

10 (h) REPLACEMENT.

Should not the first paragraph be made more specific? Manufacturer should replace wheels failing because of his defective material or workmanship, but should not be called upon to replace all wheels that break regardless of cause. As the specifications now read, the manufacturer would be called upon to replace a wheel that was defective because it broke — not one that broke because it was defective. Defense of patent litigation, etc., should be covered by contract — not by a general specification.

In general I think it may be said that the specifications as written are neither impossible nor particularly difficult to fill in the case of individual orders, material for which can be obtained by selection, provided the manufacturer has other channels through which he can dispose of such material as does not exactly meet each requirement. Such material is not necessarily inferior, but only different; for instance, it would be quite possible for a manufacturer to undertake to furnish wheels to a particular consumer, all of which should contain exactly the same carbon within the ordinary limits of sampling and laboratory conditions. This would not cause the manufacturer more trouble or expense than would be covered by a reasonable extra charge which the customer would expect to pay, but if the same limitations were

placed upon his whole output, no extra compensation would justify him in the undertaking. It would be an impossibility.

For somewhat similar reasons specifications as exacting as these submitted will work a hardship upon the small user because he cannot afford to reimburse the manufacturer for the extra cost which would be involved in applying elaborate inspection, check analysis, retests, etc., to a small lot of wheels.

The fact that a large consumer can place with the manufacturer an order of considerable size governed by unique specification, is no evidence that the same manufacturer or any other would be willing to have all the orders coming into his mill covered by a similar specification. Small consumers attempting to utilize it would find themselves compelled to waive all its "cruel and unusual" provisions.

MR. ADAMS:— In passing the specifications in this way, I do not want the idea to prevail that they will be referred to the Committee on Standards at this time; it will require further action in the future before the Committee on Standards can consider the same.

MR. TIEMANN:— Some of these points, which are now in dispute, cover features which are considered desirable, but their value has not yet been demonstrated. To cover these various points means a pretty large increase in cost, which will naturally be borne by the consumer, and it seems to us, until those points are definitely settled, it would be much better to leave them out of the specifications and make them a part of the individual contract. Some of the points are commercially almost impossible. On the other hand some of those which are possible will greatly increase the cost, and it will be a simple matter to incorporate such features in the contract.

MR. HANNA:— As I am familiar with the discussions which took place before the Committee on Standards, I would say that the idea in passing a motion of this sort is to put the specifications in a position where they will be of some service to our companies, and to adopt them, tentatively, in such form that they can be readily changed. If we adopt them in any other way, the making of any slight changes will be more

complex than if the specifications are adopted in the manner suggested by this motion. The subject automatically goes back to the Equipment Committee, and will then be referred to the Committee on Standards. In the meantime the specifications, in whole or in part, are at the service of the companies. We have heard from some of the manufacturers on this subject, but I will say, in addition, that the Committee on Standards did receive communications from some of the manufacturers stating that they were willing to take orders for wheels on the specifications as reported by the Committee.

MR. PHILLIPS:— I do not want to choke off the discussion of any subject, before a general representation of the member companies, but from my experience in drafting specifications, especially specifications dealing with steel wheels, I believe it would be much better if extended discussion should be taken up in Committee. I fear if we were to try to discuss this subject as thoroughly as it has been discussed in the past, we should be here until the middle of next week.

I wish to state in connection with these specifications of steel wheels and axles, and corroborate the statement of Mr. Hanna, that there are steel wheel manufacturers who will be very glad to make wheels according to these specifications, at no increase in price. I have that assurance, and as a matter of fact I have bought thousands of them on specifications much more rigid than this. This is also true of the axle specifications, and, before I sit down, I would like to say, as you all know, specifications drafted by associations of this sort are more or less a matter of compromise. In making specifications the ideas of no one individual can be incorporated, *in toto,* unless he is an exceptionally good man at drafting specifications and the criticism and suggestions made by the manufacturers must be given due consideration.

The Committee on Equipment feel their responsibility to the member companies first and not to the manufacturers or anyone else, nor to any other association. We are working for the member companies of the American Electric Railway Association, and before we recommend to this Association specifications, we assure ourselves that we have done all that

is possible to make these specifications such that they will produce a material that can be depended upon, and these specifications have received our most conscientious attention from that point of view.

As far as the use of these specifications is concerned, it is quite likely the larger companies will not use them in their entirety, at least quite a few of them will not; but the smaller companies who cannot afford engineering organizations will use these specifications and depend upon them, because they place great confidence in this Association and the work of its committees.

Speaking personally, there is not a specification reported by the Committee on Equipment (and it may seem singular for me to make this statement) that I would recommend for the use of my company, without modification for a reason which is counter to Mr. Tiemann's argument, in which he states they are too rigid — I say they are not rigid enough, and they are not as rigid in many respects as specifications covering the purchase of wheels and axles in lots of thousands we are buying to-day at a price which is not prohibitive or excessive and Mr. Tiemann is aware of that fact.

MR. TIEMANN:— I would like to reply to one remark of Mr. Phillips, in connection with axles — I did not state the specifications were too rigid or severe — I said there are certain revisions and suggestions which must be considered. In connection with wheels, I said there were features desired, whose value was not demonstrated and which added to the cost. It is the privilege of any manufacturer to charge any price he sees fit. My company has turned down a number of orders on account of specifications or else have charged a special price for special features involving special cost.

(The motion made by Mr. Adams was seconded, stated and carried.) (See page 818.)

MR. PHILLIPS:— There is one other matter, and that is the recommendation, on page 663, which reads as follows:

"The Central Electric Railway Association, through Mr. L. M. Clark, special representative of its Committee on Standards calls attention to slight variations between the specifications

of the American Electric Railway Engineering Association and those of the Central Electric Railway Association, covering brake shoes and axles, and we would recommend that a special Committee on Equipment be appointed to confer with the Central Electric Railway Association with a view to bringing about a common standard for both Associations."

The differences are very slight and of no great consequence, except that it is an advantage to have both specifications uniform.

PRESIDENT ACKERMAN:— It should naturally go to the Executive Committee, to appoint the committee in question, or assign the matter to a subcommittee of the Committee on Equipment. If there is no objection, it will be disposed of in that way.

MR. HANNA:— I move that the report of the Committee on Equipment be received and a vote of thanks be given the Committee for its excellent report.

(Motion duly seconded, stated and carried.)

PRESIDENT ACKERMAN:— The next order is General Business. If there is none we will have the report of the Committee on Nominations, Mr. Adams, Chairman.

MR. ADAMS:— Before presenting the report of the Committee on Nominations, I make a motion, extending the thanks of this Association to our President, Mr. Ackerman, for the able work which he has done during the past year. Mr. Ackerman has been one of the good workers of our Engineering Association and he has carried through this year's work with excellent results.

(The motion was seconded and unanimously adopted.)

PRESIDENT ACKERMAN:— Gentlemen, I want to say that I greatly appreciate the thanks which you have extended me for the work that I have done. It has been a high honor to me to be called upon to serve you as president and the work has been a pleasure to me.

REPORT OF THE COMMITTEE ON NOMINATIONS

To the American Electric Railway Engineering Association:

GENTLEMEN.— Your Committee on Nominations begs leave to report the following list of names as candidates for the various offices for the year 1912–13:

For President, Martin Schreiber, Engineer Maintenance of Way, Public Service Railway Co., Newark, N. J.

For First Vice-President, L. P. Crecelius, Electrical Engineer, The Cleveland Railway Co., Cleveland, Ohio.

For Second Vice-President, John Lindall, Superintendent Rolling Stock and Shops, Boston Elevated Railway Co., Boston, Mass.

For Third Vice-President, J. H. Hanna, Chief Engineer, Capital Traction Co., Washington, D. C.

For Secretary-Treasurer, H. C. Donecker, New York, N. Y.

For members of the Executive Committee the officers and

B. F. Wood, Assistant Engineer, Motive Power Dept., Pennsylvania Railroad Co., Altoona, Pa.

F. R. Phillips, Superintendent of Equipment, Pittsburgh Railways Co., Pittsburgh, Pa.

J. Q. Brown, Assistant to General Manager, San Francisco-Oakland Terminal Railways, Oakland, Cal.

Norman Litchfield, Engineer Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

Respectfully submitted,

H. H. ADAMS, *Chairman,*
W. J. HARVIE,
CHAS. H. CLARK,
WM. H. ROBERTS,
J. M. YOUNT,
Committee on Nominations.

MR. ADAMS:— I move you, Mr. President, that the Secretary cast one ballot for the candidates nominated.

(Motion duly seconded, stated and carried.)

SECRETARY LITCHFIELD:— The ballot is cast.

PRESIDENT ACKERMAN:— The nominees are duly elected and will now be installed. I will ask Mr. Schreiber, the new President to step forward. Mr. Schreiber, I want to congratulate you upon having been elected the Chief Executive of this Association. I present you with the gavel and I trust you will serve the Association with zeal and fidelity — and that

under your guidance the Association will grow in its magnitude and usefulness more rapidly than ever before; which will be a high honor to you and a pleasure to all the members.

PRESIDENT-ELECT SCHREIBER:— I am much obliged for this honor, and if I can only serve the Association in some small way I shall be delighted. In return for your confidence I will try to bring to the office of President, an earnest and conscientious effort to keep the work of the Association sailing along at the same high standard which it has attained under the able guidance of my predecessor.

I am very much pleased to see our newly elected Secretary and Treasurer here. The Association is very fortunate in having him accept this office, because he has a recognized habit of not beginning anything that he is not able to finish very well. I am sure that you would all like to hear a few words from him. It gives me great pleasure to introduce our new Secretary and Treasurer, Mr. H. C. Donecker.

SECRETARY-ELECT DONECKER:— I do not know that I have anything to say, except to thank you for this honor. I think it quite a personal tribute to have you ask me to serve as your Secretary, and I want to say that I appreciate it more than I can express. I know that I have a difficult undertaking in following in the footsteps of Mr. Corning and Mr. Litchfield, and keeping the work up to the standard which they have established. However, I have been in pretty close touch with their methods of administering the duties of the office, especially in the case of Mr. Litchfield, and I think that the Association owes him a debt of gratitude for the excellent work he has done. His efforts have gone a long way towards standardizing the procedure of the Association, and he has done this at great personal sacrifice of time and labor. I thank you again, gentlemen, and will do my best to please you.

PRESIDENT-ELECT SCHREIBER:— If there is no further business, a motion to adjourn is in order.

(On motion duly made and seconded the Convention adjourned *sine die.*)

CONTRIBUTORS TO DISCUSSIONS

The following is a complete list of the names, official titles and addresses of those who participated in the discussions at the Convention of the Engineering Association.

The page reference will be found in the *General Index*.

Ackerman, E. O., Engineer, Maintenance of Way, Columbus Railway & Light Co., Columbus, Ohio.
Adams, H. H., with Ford, Bacon & Davis, New York, N. Y.
Aertsen, G., Midvale Steel Co., Philadelphia, Pa.
Alden, Chas. A., Street Railway Engineer, Pennsylvania Steel Co., Steelton, Pa.
Angerer, Victor, Vice-President and General Manager, Wm. Wharton, Jr., & Co., Inc., Philadelphia, Pa.
Archibald, W. M., Engineer, Maintenance of Way, Houston Electric Co., Houston, Tex.

Barnes, J. P., Chief Engineer, Syracuse Rapid Transit Railway Co., Syracuse, N. Y.
Beach, Ralph, Federal Storage Battery Co., Silver Lake, N. J.
Bedwell, C. F., Assistant Engineer, Maintenance of Way, Public Service Railway Co., Newark, N. J.
Benedict, H. A., Mechanical Engineer, Public Service Railway Co., Newark, N. J.
Blakeslee, Robt. B., Superintendent, DuBois Traction Co., DuBois, Pa.
Boylan, M. R., General Auditor, Public Service Railway Co., Newark, N. J.
Brown, J. Q., Assistant to General Manager, San Francisco-Terminal Railways, Oakland, Cal.
Burnell, W. V., Superintendent of Construction, Houston Electric Co., Houston, Tex.

Cahill, C. A., Chief Engineer, Power Department, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.
Case, F. E., Engineer, Railway Department, General Electric Co., Schenectady, N. Y.
Choate, J. K., General Manager, Otsego & Herkimer Railroad Co., Cooperstown, N. Y.
Clark, C. H., Engineer, Maintenance of Way, The Cleveland Railway Co., Cleveland, Ohio.
Coffin, S. M., Master Mechanic, Mobile Light & Railroad Co., Mobile, Ala.

Collins, W. H., General Manager, Fonda, Johnstown & Gloversville Railroad Co., Gloversville, N. Y.
Cram, R. C., Assistant Engineer, Brooklyn Rapid Transit System, Brooklyn, N. Y.
Crecelius, L. P., Electrical Engineer, The Cleveland Railway Co., Cleveland, Ohio.

Datz, L. C., Engineer of Roadway, New Orleans Railway & Light Co., New Orleans, La.
Dodd, S. T., General Electric Co., Schenectady, N Y.
Donecker, H. C., Secretary-Treasurer, American Electric Railway Association, New York, N. Y.

Evans, J. D., Superintendent Construction and Chief Engineer, Montreal Tramways Co., Montreal, Que., Can.

Franklin, C. J., General Superintendent, Railway Department, Portland Railway Light & Power Co., Portland, Ore.
French, M. J., Engineer, Maintenance of Way, Utica & Mohawk Valley Railway Co., Utica, N. Y.

George, H. H., Assistant Engineer, Maintenance of Way, Public Service Railway Co., Newark, N. J.
Glover, M. W., Secretary and Auditor, Mobile Light & Railroad Co., Mobile, Ala.
Griffith, C. J., Treasurer and General Manager, Little Rock Railway & Electric Co., Little Rock, Ark.

Ham, W. F., Vice-President Washington Railway & Electric Co., Washington, D. C.
Hanna, J. H., Chief Engineer, Capital Traction Co., Washington, D. C.
Harries, Geo. H., President, Fargo & Moorehead Street Railway Co., Chicago, Ill.
Hazelton, Hugh, Electrical Engineer, Hudson & Manhattan Railroad Co., New York, N. Y.
Hegarty, D. A., Manager, New Orleans Railway & Light Co., New Orleans, La.
Henry, C. L., President & General Manager, Indianapolis & Cincinnati Traction Co., Indianapolis, Ind.
Hixon, L. T., Auditor, Terre Haute, Indianapolis & Eastern Traction Co., Indianapolis, Ind.
Hobein, Chas. A., Superintendent of Power Station, United Railways Company of St. Louis, St. Louis, Mo.
Hoge, James B., President, Automatic Signal & Appliance Co., Cleveland, Ohio.
Holst, E. W., Superintendent of Equipment, Bay State Street Railway Co., Boston, Mass.
Hovey, M. H., Signal Engineer, Indiana Railroad Commission, Indianapolis, Ind.

Jackson, Alexander, Superintendent of Timetables, Public Service Railway Co., Newark, N. J.
Jeffries, C. K., General Superintendent, Terre Haute, Indianapolis & Eastern Traction Co., Indianapolis, Ind.,
Johnson, H. A., Master Mechanic, Metropolitan West Side Elevated Railway Co., Chicago, Ill.

Kelker, R. F., Assistant Principal Engineer, Board of Supervising Engineers, Chicago Traction, Chicago, Il.
Kelsay, G. H., Superintendent of Power, Union Traction Company of Indiana, Anderson, Ind.

Larned, J. M., Engineer, Maintenance of Way, Pittsburgh Railways Co., Pittsburgh, Pa.
Litchfield, Norman, Engineer, Car Equipment, Interborough Rapid Transit Co., New York, N. Y.

MacRea, Thaddeus B., Auditor, Metropolitan West Side Elevated Railway Co., Chicago, Ill.
McCollum, Burton, Electrical Engineer, National Bureau of Standards, Washington, D. C.
McMillan, J., General Manager, Pacific Electric Railway, Los Angeles, Cal.
Merker, H. F., Engineer, Maintenance of Way, East St. Louis & Suburban Railway Co., East St. Louis, Ill.
Milton, T., Electric Storage Battery Co., Chicago, Ill.
Mullett, H. A., Superintendent of Rolling Stock, The Milwaukee Electric Railway & Light Co., Milwaukee, Wis.

Nachod, C. P., General Manager, Nachod Signal Co., Philadelphia, Pa.
Nicholl, H. A., General Manager, Union Traction Company of Indiana, Anderson, Ind.
Nicholson, W. G., Auditor, Omaha & Council Bluffs Street Railway Co., Omaha, Neb.

Page, Wilson K., Electrical Engineer, Western New York and Pennsylvania Traction Co., Olean, N. Y.
Palmer, G. W., Jr., Electrical Engineer, Bay State Street Railway Co., Boston, Mass.
Penoyer, B., Engineer, Maintenance of Way, Schenectady Railway Co., Schenectady, N. Y.
Phillips, F. R., Superintendent of Equipment, Pittsburgh Railways Co., Pittsburgh, Pa.
Potter, W. B., Engineer, Railway and Truck Department, General Electric Co., Schenectady, N. Y.

Rice, Ralph H., Electrical Engineer, Board of Supervising Engineers, Chicago Traction, Chicago, Ill.
Richey, A. S., Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass.
Roberts, Wm., Superintendent of Power, Northern Ohio Traction and Light Co., Akron, Ohio.
Rockwell, W. B., Manager, Eastern Pennsylvania Railways Co., Pottsville, Pa.
Rust, T. E., Chief Engineer, Waterloo, Cedar Falls and Northern Railway Co., Waterloo, Ia.

Salber, W. E., Superintendent of Power, Northern Ohio Traction and Light Co., Akron, Ohio.
Sawyer, Wm. H., with Ford, Bacon & Davis, New York, N. Y.
Schreiber, J. Martin, Engineer, Maintenance of Way, Public Service Railway Co., Newark, N. J.
Shannahan, J. N., Vice-President and General Manager, Newport News & Old Point Railway & Electric Co., Hampton, Va.
Sibbald, John, Master Mechanic, Fonda, Johnstown & Gloversville Railroad Co., Gloversville, N. Y.
Simmons, F. J., Commissioner, Board of Public Works, Milwaukee, Wis.
Slocum, F. S., Metallurgist, Jones & Laughlin Steel Co., Pittsburgh, Pa.
Smith, R. P., Superintendent and Purchasing Agent, Frederick Railroad Co., Frederick, Md.
Storer, N. W., Engineering Department, Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa.

Thompson, Gaylord, Chief Engineer, Ohio Electric Railway Co., Cincinnati, Ohio.
Tiemann, H. P., Metallurgical Engineer, Carnegie Steel Co., Pittsburgh, Pa.

Waldron, J. M., Signal Engineer, Interborough Rapid Transit Co., New York, N. Y.
Wilson, Geo. L., Engineer, Maintenance of Way, Twin City Rapid Transit Co., Minneapolis, Minn.
Wilson, H. L., Treasurer, Boston Elevated Railway Co., Boston, Mass.

Young, C. G., Consulting Engineer, New York, N. Y.

CONSTITUTION AND BY-LAWS

OF THE

AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION

CONSTITUTION

Name

I. The name of the association shall be the "American Electric Railway Engineering Association," and its office shall be at the place where the secretary resides.

Objects

II. The objects of this association shall be to bring together those engaged in electric railway engineering with urban, interurban or the electrified sections of steam railways, for the interchange of ideas, to acquire and distribute information and to promote uniformity of practice.

Members

III. The membership of this association shall consist of two classes, as follows:

(a) Active members, consisting of active members of the American Electric Railway Association. Each active member shall be entitled to one vote on all questions coming before this association, which shall be cast by a properly accredited representative of its mechanical, electrical, way or engineering departments. Each active member shall send as many delegates from the engineering departments as it may desire.

(b) Associate members, consisting of associate members of the American Electric Railway Association, who may elect to ally themselves with this association.

Amendment

IV. This constitution may be amended by a two-thirds vote of the members present at a regular meeting, provided the proposed amendment shall have the approval of two-thirds of the executive committee, and provided also that a copy shall have been sent to each of the active members, at least thirty days prior to the date of the meeting at which the proposed amendment is to be acted upon.

BY-LAWS

Officers and Executive Committee

I. The officers shall consist of a president, three vice-presidents. a secretary and treasurer, and the executive committee, the latter to consist of four active members, and all the past presidents of the American Electric Railway Engineering Association and its predecessors, The American Street and Interurban Railway Engineering Association and the American Railway Mechanical and Electrical Association, these past presidents to be honorary members of the executive committee, but without power to vote at meetings of the committee. The executive committee shall have the entire charge and management of the affairs of the association. The officers and active members of the executive committee shall be elected by ballot at each annual meeting of the association, and shall hold office until their successors shall be elected. The officers of this association shall be chosen from the mechanical, electrical, way or engineering departments of active members. The duties of secretary and treasurer shall be performed by the same person.

Duties of Officers

II. The officers of the association shall assume their duties immediately after the close of the meeting at which they are elected. They shall hold meetings at the call of the president, or, in his absence, at the call of the vice-presidents, in their order, and make arrangements for carrying out the objects of the association. In case of resignation or death of an officer or a member of the executive committee, the vacancy may be filled for the unexpired term by the executive committee.

President

III. The president shall be the chief executive officer of the association. The president, if present, or in his absence one of the vice-presidents, in their order, if present, shall preside at all meetings of the association, and of the executive committee, and shall represent this association on the executive committee of the American Electric Railway Association.

Secretary and Treasurer

IV. The duties of the secretary and treasurer shall be as follows:

(a) To receive and safely keep all moneys of the association, to keep correct accounts of the same, and to pay all bills approved by the president. He shall make an annual report to be submitted to the association. He shall give a bond to the president in such a sum and with such sureties as shall be approved by the executive committee. He shall be paid a salary fixed by the executive committee.

(b) To take minutes of all the proceedings of the association and of the executive committee, and to enter them in books kept for the purpose.

(c) To conduct the correspondence of the association.

(d) To read minutes and notices at all meetings, and to present papers and communications, if the authors wish it.

(e) To collect and file for the benefit of the members information regarding matters relating to the purposes of the association.

(f) To attend to the publication of the proceedings of this association in connection with the secretary of the American Electric Railway Association.

(g) To send notices to all members of the association at least thirty days before each meeting, mentioning papers to be read and any special business to be brought before the meeting.

(h) To perform such other duties as may be required of him by the constitution and by-laws, and such duties as may be assigned him by the executive committee.

Executive Committee

V. (a) The executive committee shall hold a regular meeting before each regular annual meeting of the association, and shall hold such special meetings as may be necessary. Such special meetings may be called by the president, or any five members of the executive committee. A majority of the members of the executive committee shall constitute a quorum at all meetings. A vote of the executive committee may be taken by mail when deemed necessary by the president.

(b) The secretary shall give such reasonable notice of all meetings as the committee shall by vote prescribe, and all such notices shall, as far as practicable, specify the business to be brought to the attention of the committee at such meetings.

(c) The executive committee shall present a report to each regular annual meeting of the association, and shall include in such report the names of the members elected during the year, and its recommendations for the future work of the association.

Meetings

VI. The regular annual meeting of this association shall convene at a time and place to be approved by the executive committee. Special meetings may be held upon the order of the executive committee. Notice of every meeting shall be given by the secretary in a circular addressed to the members at least thirty days before the time of meeting. Fifteen members shall constitute a quorum at any meeting.

Order of Business

VII. At the regular meeting of the association the order of business shall be:

1. Reading of the minutes of the last meeting.
2. Address of the president.
3. Report of the executive committee.
4. Report of the secretary and treasurer.
5. Reports of special committees.
6. Reading and discussion of papers.
7. General business.
8. Election of officers.

At other general meetings of the association the order of business shall be the same, except as to the 3d, 4th and 8th clauses.

Voting

VIII. All votes, except as herein otherwise provided, shall be *viva voce,* or by ballot upon the request of any member, and in the case of a tie, the presiding officer shall vote.

Reading of Papers

IX. All papers read at the meetings of the association must relate to matters connected with the objects of the association, and must have the approval of the executive committee before being read. Persons to whom subjects are assigned must signify in writing their intention to prepare the paper, and forward it to the secretary at least sixty days previous to the date of the meeting.

Papers, Illustrations and Models

X. All papers, illustrations and models submitted to the meeting of the association shall remain the property of the owners; subject, however, to retention by the executive committee for examination and use, but at the owners' risk.

Rules of Order

XI. All rules not provided for in these by-laws shall be found in "Roberts' Rules of Order."

XII. All propositions for adding to or altering any of these by-laws shall be laid before the executive committee, which shall bring them before the next regular meeting of the association if it shall consider such course desirable; and it shall be the duty of the committee to do so, on the request, in writing, of any five members of the association.

Copy of Constitution and By-Laws

XIII. Each member of the association shall be furnished by the secretary with a copy of the constitution and by-laws of the association and also a list of the members.

MEMBER COMPANIES AND THEIR ENGINEERING OFFICERS

(Arranged Alphabetically According to the Names of the Company.)

ALABAMA CITY, GADSDEN AND ATTALLA RAILWAY CO., Gadsden, Ala.

Superintendent and Electrical Engineer, C. J. Zell.

ALBANY SOUTHERN RAILROAD CO., Albany, N. Y.

General Mechanical and Electrical Superintendent, R. P. Leavitt; Superintendent Railroad, N. H. Brown; Chief Engineer and Engineer Power Station, T. H. Ceperley; Master Mechanic, Geo. W. Osburn; Roadmaster, John Clark.

ALGIERS RAILWAY & LIGHTING CO., New Orleans, La.

General Manager, C. E. A. Carr; Chief Engineer, O. U. Vernuille.

ALLEN STREET RAILWAY CO., Nazareth, Pa.

General Manager, Purchasing Agent and Chief Engineer, N. K. Putnam.

ALTOONA & LOGAN VALLEY ELECTRIC RAILWAY CO., Altoona, Pa.

Superintendent Construction, F. D. Hain; Engineer Power Plant, Jas. Honor; Master Mechanic, W. H. Rushton.

ANNISTON ELECTRIC & GAS CO., Anniston, Ala.

General Manager and Purchasing Agent, R. L. Rand; Electrician and Chief Engineer of Power Station, W. H. Rudisill; Master Mechanic, John M. Bowles; Roadmaster, J. J. Cook.

APPALACHIAN POWER COMPANY, Bluefield, W. Va.

Superintendent Power Department, H. E. Shedd; Chief Engineer Power Station, J. H. Crantz.

ARKANSAS VALLEY INTERURBAN RAILWAY CO., Wichita, Kans.

Superintendent, Purchasing Agent and Chief Engineer, Chas. D. Bell; Master Mechanic, C. W. Geiger; Roadmaster, A. J. Curteman.

THE ARKANSAS VALLEY RAILWAY, LIGHT & POWER CO., Pueblo, Colo.

Superintendent Power Plant, Machinery and Shops, C. M. Caster; Superintendent Lighting, Power and Distribution, E. F. Stone.

AROOSTOCK VALLEY RAILROAD CO., Presque Isle, Me.

Electrical Engineer, Power Generation and Distribution, C. O. Austin; Engineer Maintenance of Way, Structures and Equipment, M. S. W. Dingwall.

ASHEVILLE & EAST TENNESSEE RAILROAD, Asheville, N. C.

Chief Engineer, H. L. Parker.

ASHEVILLE POWER AND LIGHT CO., Asheville, N. C.

Superintendent and Chief Engineer, J. C. Donald; Chief Engineer Power Station, M. P. Lawrence; Roadmaster, O. W. Cooper.

ATHENS RAILWAY & ELECTRIC CO., Athens, Ga.

General Superintendent and Purchasing Agent, C. L. Proctor; Superintendent Lines, J. J. Fowler; Engineer Power Station, H. M. Hughes; Master Mechanic and Roadmaster, Robt. G. Davis.

ATLANTA-MACON RAILWAY COMPANY, Atlanta, Ga.

President, Kennett Cowan.

ATLANTIC COAST ELECTRIC RAILWAY CO., Asbury Park, N. J.

Superintendent Maintenance of Way, C. E. Hereth; Master Mechanic and Superintendent of Power Station, J. H. Moor; General Manager, Purchasing Agent and in charge of all Buildings, S. F. Hazelrigg

ATLANTIC SHORE RAILWAY, Kennebunk, Me.

General Manager and Purchasing Agent, L. H. McCray; Electrical Engineer, F. M. Richards; Master Mechanic, W. J. Dunston.

AUGUSTA-AIKEN RAILWAY & ELECTRIC CORP., Augusta, Ga.

Chief Engineer and Purchasing Agent, John H. Adams; Superintendent Electrical Department, J. J. Borger; Chief Engineer Power Station, A. W. Look.

AURORA, ELGIN & CHICAGO RAILROAD CO., Wheaton, Ill.

Engineer Maintenance of Way, C. J. Jones; Assistant to the General Manager and Engineer, Edward F. Gould; Master Mechanics, E. P. Doyle and W. J. Bowman; Chief Engineer Power Station, D. Sutherland; Roadmaster Third-Rail Division, John Carlson; Roadmaster Fox River Division, P. J. Downey; Purchasing Agent, W. P. Harvey.

AUSTIN STREET RAILWAY CO., Austin, Tex.

Superintendent Equipment and Way, Buildings and Fixtures, W. H. Burdett; Chief Engineer Power Station, H. D. Odell; Electrical Engineer, Louis Eggling.

THE BALTIMORE & BEL-AIR ELECTRIC RAILWAY CO., Bel-Air, Md.

General Manager and Purchasing Agent, J. Alexis Shriver.

BANGOR RAILWAY & ELECTRIC CO., Bangor, Me.

Engineer, C. M. Tolman; Superintendent, C. H. Johnson; Master Mechanic, Morris McCormick; Purchasing Agent, W. L. Sawtelle.

BARTLESVILLE INTERURBAN RAILWAY CO., Bartlesville, Okla.

Chief Engineer Power Plant, C. C. Ditto; Superintendent Equipment, W. H. Forrest; Superintendent Ways, C. Wilker.

BATON ROUGE ELECTRIC CO., Baton Rouge, La.

Superintendent Railway, R. A. Delaroderie; Master Mechanic, A. Cason.

BAY STATE STREET RAILWAY CO., Boston, Mass.

Roadmaster, David Curtin; Superintendent Motive Power and Machinery, Chas. F. Bancroft; Electrical Engineer, Geo. W. Palmer, Jr.; Superintendent Equipment, E. W. Holst; Superintendent Power Stations, A. L. Ward; Purchasing Agent, C. R. Rockwell.

BEAUMONT TRACTION CO., Beaumont, Tex.

Receiver, James F. Weed; General Manager, Purchasing Agent and Electrical Engineer, C. H. Kretz; Engineer Power Station, Tandy Turnley.

BENTON HARBOR-ST. JOE RAILWAY & LIGHT CO., Benton Harbor, Mich.

General Manager, H. C. Mason; Master Mechanic, Jos. F. Logan; Chief Engineer Power Station, Geo. J. Spalding.

BINGHAMTON RAILWAY CO., Binghamton, N. Y.

General Manager and Purchasing Agent, J. P. E. Clark; Chief Engineer and Master Mechanic, F. W. Summers; Roadmaster, G. M. Weslar.

BIRMINGHAM RAILWAY, LIGHT & POWER CO., Birmingham, Ala.

Engineer, T. R. H. Daniels; Assistant Engineer, G. C. Estill; Master Mechanic, F. M. Weld; Roadmaster, H. J. Kribs; Chief Engineer Power Plant, D. J. O'Brien.

BOSTON & WORCESTER STREET RAILWAY CO., Boston, Mass.

General Manager and Purchasing Agent, E. P. Shaw; Civil Engineer, E. H. Howard; Electrical and Mechanical Engineer, F. L. O'Bryan; Chief Engineer Power Station, C. B. Smith; Master Mechanic, E. S. McLain; Roadmaster, Joseble Johnson.

BOSTON ELEVATED RAILWAY CO., Boston, Mass.

Chief Engineer Maintenance of Way, H. M. Steward; Civil Engineer, A. L. Plimpton; Roadmaster Elevated Division, A. L. Butler; Roadmaster Surface Lines, Thos. F. Sullivan; Chief Engineer of Motive Power and Rolling Stock, Paul Winsor; Superintendent of Rolling Stock and Shops, John Lindall; Superintendent of Car Shops, H. L. Libby; Superintendent of Albany Street Shops, F. W. Garrett; Superintendent of Power Stations, Jas. D. Andrew; Superintendent of Power Distribution, W. T. Masters; Electrical Engineer, John W. Corning; Designing Engineer, Robert B. Davis; Architect and Acting Superintendent of Buildings, F. F. Low; Purchasing Agent, Edw. Mahler.

BRIDGETON & MILLVILLE TRACTION CO., Bridgeton, N. J.

Electrician and Master Mechanic, A. M. Sharp; Chief Engineer, C. F. W. Meyers; Purchasing Agent, W. J. Mulholland.

BRITISH COLUMBIA ELECTRIC RAILWAY CO., LTD., Vancouver, B. C.

Chief Engineer, G. R. G. Conway; Mechanical Superintendent, S. B. Thompson; Electrical Engineer, W. V. Hunt; Purchasing Agent, W. H. Hazlitt; Construction Engineer, C. B. Vorce.

BROCTON & PLYMOUTH STREET RAILWAY CO., Plymouth, Mass.

Resident Manager and Purchasing Agent, Howard F. Eaton; Chief Engineer Power Station, W. R. Morton; Master Mechanic, George Semple.

BROOKLYN HEIGHTS RAILROAD CO. (THE), Brooklyn, N. Y.

Superintendent of Equipment, W. G. Gove; Engineer of Way and Structure, C. L. Crabbs; Electrical Engineer, C. E. Roehl; Superintendent of Power, H. A. Robbins; Purchasing Agent, Lincoln Van Cott.

BUCKS COUNTY ELECTRIC RAILWAY CO., Newtown, Pa.

General Manager and Purchasing Agent, W. H. Janney; Chief Engineer, G. W. Ettenger.

BUFFALO & LAKE ERIE TRACTION CO., Buffalo, N. Y.

Assistant General Manager and Chief Engineer, A. R. Myers; Chief Engineer Power Station, J. S. Shaughnessey; Purchasing Agent, A. F. Tideswell; Roadmaster, C. M. Harrison.

BURLINGTON COUNTY TRANSIT COMPANY, Hainesport, N. J.

Superintendent, John M. Smith; Track Foreman, Owen Joyce.

BUTTE ELECTRIC RAILWAY CO., Butte, Mont.

General Superintendent, J. S. Wathey; Mechanical Engineer, C. H. Bucher; Chief Electrician, Frank McTucker; Track Foreman, Wm. Stephenson.

CAPE BRETON ELECTRIC CO., LTD., Sydney, N. S., Canada.

Superintendent of Railway, J. B. Bulley; Electrical Engineer, W. M. B. Macdonald; Master Mechanic, James Sharpe; Chief Engineer Power Station, D. Webber.

CAPITAL TRACTION CO. (THE), Washington, D. C.

Chief Engineer, J. H. Hanna; Electrical Engineer of Equipment, Power Distribution and Sub-stations, R. H. Dalgleish; Engineer of Power Stations, C. J. Hoshall; Master Mechanic of Shops, W. H. McCarty; Roadmaster of Track, Roadway and Line, F. Morrill; Assistant Engineer of Track, Roadway and Line, H. P. Huntting.

CARBON TRANSIT CO., Mauch Chunk, Pa.

Electrical Engineer, J. F. Geiser.

CEDAR RAPIDS & IOWA CITY RAILWAY & LIGHT CO., Cedar Rapids, Ia.

Superintendent Railway and Chief Engineer, J. D. Wardle; Electrical Engineer and Master Mechanic, Chas. Munson; Electrical Engineer, F. W. Laas.

CEDAR RAPIDS & MARION CITY RAILWAY CO., Cedar Rapids, Ia.

Mechanical and Electrical Engineer, F. M. Ford; Master Mechanic, Elmer Veley.

CENTRAL CALIFORNIA TRACTION CO., San Francisco, Cal.

Chief Engineer, F. C. Miller; Master Mechanic, F. A. Miller; Roadmaster, R. L. Lowry; Purchasing Agent, F. W. Smith.

CENTRAL ILLINOIS PUBLIC SERVICE CO., Mattoon, Ill.

Electrical Engineer, A. J. Authenreith; Master Mechanic, W. M. Storm; Roadmaster, M. Jones.

CENTRAL PENNSYLVANIA TRACTION CO., Harrisburg, Pa.

Electrician, P. F. Gerhart; Engineer, D. B. Moist; Master Mechanic, A. F. Rexroth; Purchasing Agent, J. O'Connell; Engineer Power Station, John Gehr; Track Foreman, J. M. Anderson.

CHARLESTON CONSOLIDATED RAILWAY AND LIGHTING CO., Charleston, S. C.

Purchasing Agent, M. K. Palmer; Electrical Engineer, W. J. Pollock; Chief Engineer Power Station, J. O. Moisson; Master Mechanic, F. H. Harris; Roadmaster, L. T. Dawson.

CHARLOTTE ELECTRIC RAILWAY CO., Charlotte, N. C.

Engineer Maintenance and Equipment, E. F. Taylor; Electrical Engineer, E. P. Taylor; Chief Electrician, J. C. Mullen; Engineer Power Station, J. B. Linker; Roadmaster, S. A. Hunter.

CHATTANOOGA RAILWAY & LIGHT CO., Chattanooga, Tenn.

Chief Engineer, E. D. Reed; First Assistant Engineer, E. R. Dike; Second Assitant Engineer, E. G. Murrell; Electrical Engineers, O. B. Agner, Carl Rigdon, E. C. Williamson; Master Mechanic, Reuben Nave.

CHICAGO, AURORA & DE KALB RAILROAD CO., Aurora, Ill.

Master Mechanic, W. J. Jones; Roadmaster, Floyd Clark.

CHICAGO & INTERURBAN TRACTION CO., Chicago, Ill.

President, John L. Matson.

CHICAGO & JOLIET ELECTRIC RAILWAY CO., Joliet, Ill.

Engineer Ways and Structures, John B. Tinnon; Assistant Engineer (American Railways Co., Philadelphia, Pa.), A. P. Way; Superintendent Motive Power, G. S. Patterson; Electrical Engineer, C. P. Deiterick; Roadmaster, J. P. McCulloch; Purchasing Agent, W. L. Mulholland.

CHICAGO CITY RAILWAY CO., Chicago, Ill.

Purchasing Agent, F. C. Evans; Superintendent Wires and Cables, A. A. Thurlby; Superintendent Power Plants, M. J. Callaghan; Master Mechanic, Donald McGill; Superintendent of Tracks, W. F. Graves.

CHICAGO, LAKE SHORE & SOUTH BEND RAILWAY CO. (THE), Michigan City, Ind.

Engineer of Way and Structures, J. A. Forsyth; Superintendent of Power, W. E. Rolston; Master Mechanic, C. E. Heslet.

CHICAGO RAILWAY CO., Chicago, Ill.

Chief Engineer, J. Z. Murphy; Purchasing Agent, N. M. Thorsson; General Roadmaster, Charles A. Caul; Chief Engineers Power Stations, J. Allen and Patrick O'Connell.

CHICAGO, SOUTH BEND & NORTHERN INDIANA RAILWAY CO., South Bend, Ind.

Master Mechanic, C. E. Atkinson; Superintendent of Overhead, D. C. Southworth; Superintendent of Sub-stations, L. J. Miller; Roadmaster, P. J. Conley; Assistant to Engineer, S. E. Emmons; Storekeeper, R. E. Cornwell.

CHILLICOTHE ELECTRIC RAILROAD, LIGHT & POWER CO., Chillicothe, O.

General Manager, George A. Vaughters; Assistant Manager and Purchasing Agent, F. K. Sexauer; Engineer Power Station, Chas. Waymier; Roadmaster, John Byers.

CHIPPEWA VALLEY RAILWAY, LIGHT & POWER CO., Eau Claire, Wis.

Assistant Manager, A. E. Peirce; Purchasing Agent, Geo. B. Wheeler.

CINCINNATI, LAWRENCEBURG & AURORA ELECTRIC STREET RAILROAD CO., Cincinnati, O.

Purchasing Agent, E. M. Gumpf; Chief Engineer of Power Station, Philip Hans; Master Mechanic, Geo. Bender.

CINCINNATI TRACTION CO. (THE), Cincinnati, O.

Chief Engineer, Thos. Elliott; Assistant Chief Engineer, Wm. Mittendorf; Superintendent of Overhead Construction, H. L. Grant; Engineer of Roadways, E. H. Berry; Superintendent of Construction (Track), F. J. Venning; Purchasing Agent, C. Burckmyer; Superintendent Steam Machinery, H. C. Rolf; Superintendent Shops, Eugene Flinghuff.

CITIZENS' TRACTION COMPANY (THE), Oil City, Pa.

General Manager, F. D. Shaffer; Chief Engineer Power House, Chas. Monks; Master Mechanic, W. M. Jones; Supervisor, T. W. Parsons; Chief Lineman, A. N. Lund.

CLEVELAND, PAINESVILLE & EASTERN RAILROAD CO. (THE), Willoughby, O.

Superintendent Power and Shops, J. G. Swain; Roadmaster, L. J. Rider; Engineer Maintenance of Way, W. F. Aid; Master Mechanic, P. J. Wood.

CLEVELAND RAILWAY CO. (THE), Cleveland, O.

Engineer Maintenance of Way, C. H. Clark; Superintendent of Power, L. P. Crecelius; Master Mechanic, Terrance Scullin; Purchasing Agent, Chas. H. Stanley.

CLEVELAND, SOUTHWESTERN & COLUMBUS RAILWAY CO. (THE), Cleveland, O.

Superintendent Power and Shops, A. P. Lewis.

CLINTON STREET RAILWAY CO., Clinton, Ia.

Superintendent and Purchasing Agent, B. Bohnson.

COLORADO SPRINGS & INTERURBAN RAILWAY CO., Colorado Springs, Colo.

Superintendent and Purchasing Agent, B. M. Lathrop; Chief Engineer Power Station, C. E. Bibb; Master Mechanic, J. H. Eastwood; Roadmaster, C. E. Elliott; Line Foreman, E. O. Flagg.

COLUMBIA RAILWAY, GAS & ELECTRIC CO., Columbia, S. C.

Superintendent of Railway (in charge of Way Matters, Equipment, Buildings and Structures), Alfred Wallace; Electrical Engineer (in charge of Power Generation and Distribution), William M. Shannon.

COLUMBUS RAILROAD CO., Columbus, Ga.

Trackmaster, W. B. Buchanan; Superintendent of Power, Charles M. Young; Master Mechanic, H. K. Jarvis.

COLUMBUS RAILWAY & LIGHT CO., Columbus, O.

Master Mechanic, Charles E. Hott; Electrical Engineer, R. J. Feather; Engineer of Way, E. O. Ackerman; Chief Engineer Power Station, F. R. Brosius; Purchasing Agent, Curtis C. Collins.

CONCORD, MAYNARD & HUDSON STREET RAILWAY CO., Maynard, Mass.

Master Mechanic, Frank A. Marsh; Chief Engineer Power Station, William L. Stone; Roadmaster, Henry Hutchby.

CONESTOGA TRACTION CO., Lancaster, Pa.

Engineer, H. W. Crawford; Superintendent of Rotaries, W. F. Kneezel; Master Mechanic, F. D. Connelly; Superintendent of Overhead Department, H. W. Baubaker; Consulting Engineer, Prof. J. E. Kershner.

CONEY ISLAND & BROOKLYN RAILROAD CO., Brooklyn, N. Y.

Chief Engineer, Stonewall Tompkins; Engineer of Way and Structure, E. L. Mathews; Superintendent of Power Plants, C. A. Wilkinson; Superintendent of Line Department, H. L. Coker; Master Mechanic, G. C. Killeen; Purchasing Agent, H. B. Lingeman; Assistant to Chief Engineer, R. A. Paine, Jr.

CONNECTICUT COMPANY (THE), New Haven, Conn.

Supervisor Power Plants, E. S. Cooley; Electrical Engineer, D. S. Miller; Engineer, E. C. Webster; Manager of Purchases and Supplies, H. A. Fabian; Purchasing Agent, J. H. Sanford.

COUNTY TRACTION CO., Chicago, Ill.

General Superintendent, F. C. Chambers.

CUMBERLAND & WESTERNPORT ELECTRIC RAILWAY CO., Cumberland, Md.

Purchasing Agent, D. P. Hartzell; Master Mechanic, D. D. Price.

DALLAS CONSOLIDATED ELECTRIC STREET RAILWAY CO., Dallas, Tex.

Engineer of Way and Structures, B. R. Brown; Electrical Engineer, Edward Oran; Master Mechanic, J. L. Brown.

DANBURY & BETHEL STREET RAILWAY CO., Danbury, Conn.

Electrical and Mechanical Engineer, John Sanders; Purchasing Agent and Master Mechanic, Geo. R. Tweedy; Power Station Engineer, S. E. Whitaker; Chief Electrician, William Rosenbaum; Roadmaster, Martin Kane.

DANVILLE TRACTION & POWER CO., Danville, Va.

Superintendent and Purchasing Agent, N. W. Berkeley; Chief Engineer, Electrician and Master Mechanic, J. M. King; Engineer Power Station, J. D. Logan.

DAYTON, COVINGTON & PIQUA TRACTION CO., West Milton, O.

Chief Engineer, H. A. Cecil; Master Mechanic, A. C. Kelsey; Roadmaster, Jas. Cox.

DAYTON, SPRINGFIELD & XENIA SOUTHERN RAILWAY CO. (THE), Dayton, O.

General Manager and Purchasing Agent, T. A. Ferneding; Engineer Power Station, Edw. Marshall; Master Mechanic, Ira Scofield.

DAYTON & TROY ELECTRIC RAILWAY CO. (THE), Tippecanoe City, O.

General Manager and Purchasing Agent, R. A. Crume; Superintendent of Motive Power, Keppele Hall; Engineer Power Station, Waldo Weaver; Master Mechanic, H. F. Ferguson; Chief Engineer Power Station, Waldo Weaver.

DENVER CITY TRAMWAY CO. (THE), Denver, Colo.

Chief Engineer, John Evans; Assistant Engineer, R. W. Toll; Superintendent of Tracks, A. M. Evans; Electrical Engineer, Norman Read; Superintendent of Power, J. F. Warner; Superintendent Overhead Lines, W. G. Matthews; Superintendent of Rolling Stock, W. H. McAloney.

DETROIT UNITED RAILWAY, Detroit, Mich.

Superintendent of Power, E. J. Burdick; Superintendent of Tracks and Buildings, John Kerwin; Master Mechanic, Sylvester Potter.

DOUGLAS TRACTION & LIGHT CO., Douglas, Ariz.

General Manager and Purchasing Agent, R. G. Arthur.

DULUTH STREET RAILWAY CO. (THE), Duluth, Minn.

Chief Engineer, John Carson; Master Mechanic, R. J. Crawford; Roadmaster, Thos. A. Armstrong; Purchasing Agent, A. A. Mendenhall.

EASTERN PENNSYLVANIA RAILWAYS CO., Pottsville, Pa.

Electrical Superintendent, I. G. Walborn; Master Mechanic, N. M. Lentz.

EAST ST. LOUIS & SUBURBAN RAILWAY CO., East St. Louis, Ill.

General Superintendent and Purchasing Agent, A. J. Purinton; Engineer Power Station, P. S. Tuncil; Engineer Maintenance of Way, H. F. Merker; Roadmaster, J. C. Dew; Electrical Engineer and Acting Master Mechanic, H. J. Parks.

EASTON TRANSIT CO., Easton, Pa.

Master Mechanic, Robert C. Green; Engineer Maintenance of Way, C. E. Jenkins; Overhead Line Foreman, Frank Crick.

EASTERN WISCONSIN RAILWAY & LIGHT COMPANY, Fond du Lac, Wis.

Superintendent and Master Mechanic, W. J. Kelsh; Chief Engineer, C. A. Ewing; Chief Engineer Power Station, A. G. Carson.

ELGIN & BELVIDERE ELECTRIC CO., Chicago, Ill.

Master Mechanic, W. P. Hendricks; Chief Engineer, F. A. Sager.

ELMIRA WATER, LIGHT & RAILROAD CO., Elmira, N. Y

Superintendent of Railroad Department (in charge of Maintenance of Way and Car Operation), F. G. Maloney; Superintendent of Electric Department (in charge of Power Generation and Distribution), C. M. Bange; Roadmaster, Paul Mantle; Master Mechanic, John Creighton.

EL PASO ELECTRIC RAILWAY CO., El Paso, Texas.

Chief Engineer, C. L. Forsyth; Master Mechanic, A. C. Woehler.

ENID CITY RAILWAY CO., Enid, Okla.

Superintendent and Purchasing Agent, C. Kline; Master Mechanic, W. R. Fitzgerald; Roadmaster, L. Pritchard.

ESCANABA TRACTION CO., Escanaba, Mich.

General Manager and Purchasing Agent, P. L. Utley; Chief and Electrical Engineer, Erwin Zuelke; Master Mechanic, Edw. Anderson; Roadmaster, J. Burke.

EVANSVILLE RAILWAYS CO., Evansville, Ind.

General Manager and Purchasing Agent, W. A. Carson; Superintendent of Motive Power, T. R. Crumley; Chief Engineer Power Station, C. O. Maxwell; Roadmaster, E. W. Wheeler.

EVERETT RAILWAY, LIGHT & WATER CO., Everett, Wash.

Manager, D. C. Barnes; Chief Engineer Power Station, D. B. Young; Master Mechanic, Fred A. Berg.

EXETER, HAMPTON & AMESBURY STREET RAILWAY, Hampton, N. H.

Manager and Purchasing Agent, J. A. MacAdams; Shop Foreman, Geo. E. Moore; Roadmaster, J. Raney.

FARGO & MOOREHEAD STREET RAILWAY CO., Fargo, N. D.

Managers and Engineers, H. M. Byllesby & Co., Chicago, Ill.; General Superintendent and Purchasing Agent, C. P. Brown.

FISHKILL ELECTRIC RAILWAY CO., Fishkill-on-the-Hudson, N. Y.

Manager, J. T. Smith; Chief Engineer, John Donnelley; Engineer Power Station, Grant Gardner.

FITCHBURG & LEOMINSTER STREET RAILWAY CO., Fitchburg, Mass.

Superintendent Motive Power, Chas. R. Putnam; Roadmaster, Benjamin F. Ordway.

FONDA, JOHNSTOWN & GLOVERSVILLE RAILROAD CO., Gloversville, N. Y.

Chief Engineer Way Matters and Power Distribution, F. A. Bagg; Master Mechanic (Equipment, Heavy Electric Traction and Building and Structures), John Sibbald; Purchasing Agent, L. A. Hall.

FORT SMITH LIGHT & TRACTION CO., Fort Smith, Ark.

Chief Engineer, L. R. Robertson; Electrical Engineer, A. Patterson; Master Mechanic, George Chynoweth.

FORT WAYNE & NORTHERN INDIANA TRACTION CO., Fort Wayne, Ind.

Superintendent Maintenance of Way, J. J. Brennan; Assistant Engineer Maintenance of Way, H. V. Norford; Electrical Engineer, E. S. Myers; Superintendent Motive Power, F. J. Stevens; Chief Engineer Spy Run Power Station, A. P. Singer.

FORT WAYNE & SPRINGFIELD RAILWAY CO. (THE), Decatur, Ind.

Chief Engineer, A. M. Fishbaugh; Chief Engineer Power Station, W. F. Burns; Mechanical Engineer, C. H. Brode; Roadmaster, A. M. Henry.

FREDERICK RAILROAD CO., Frederick, Md.

Superintendent and Purchasing Agent, R. Paul Smith; Chief Engineer, O. B. Coblentz; Engineer Power Stations, William Eader; Master Mechanic, G. E. Stine; Electrical Engineer, H. B. Baird.

FREEPORT RAILWAY & LIGHT CO., Freeport, Ill.

Purchasing Agent, A. J. Goddard; Chief Engineer, Knox Engineering Co.; Master Mechanic, Wm. Green; Roadmaster, Henry Gale.

FRESNO TRACTION CO., Fresno, Cal.

General Purchasing Agent, F. W. Taylor; Track Foreman, Alex Maneely.

FRIES MANUFACTURING & POWER CO. (THE), Winston-Salem, N. C.

Purchasing Agent and Electrical Engineer, J. J. Sigg; Track Foreman, Frank Cumbe.

GALESBURG & KEWANEE ELECTRIC RAILWAY CO., Kewanee, Ill.

General Manager and Purchasing Agent, R. H. Hayward; Master Mechanic, Vernon Mellott.

GALVESTON ELECTRIC CO., Galveston, Tex.

Master Mechanic, M. B. Osborne; Chief Engineer, C. Learmonth.

GARDNER, WESTMINSTER & FITCHBURG STREET RAILROAD CO., Gardner, Mass.

Manager and General Purchasing Agent, C. A. Jefts; Chief Engineer and Engineer Power Station, E. Rumery; Master Mechanic, E. S. Bates; Engineer and Superintendent of Ways, C. W. Clapp; Purchasing Agent, M. H. Merrill.

GENEVA & AUBURN RAILWAY CO., Seneca Falls, N. Y.

Chief Engineer Power Station, George Everill; Master Mechanic, C. D. Skuse.

GRAND FORKS STREET RAILWAY CO., Grand Forks, N. D.

General Manager (in charge of all Engineering Departments), Thomas Roycraft; Electrical Engineer, C. H. Rogers.

GRAND JUNCTION & GRAND RIVER VALLEY RAILWAY CO. (THE), Grand Junction, Colo.

Chief Engineer, Frank C. Merriell; Electrical Engineer and Superintendent of Power Stations, A. C. Foster; Master Mechanic, J. N. Hinds; Roadmaster, J. E. O'Hara.

GRAND RAPIDS, GRAND HAVEN & MUSKEGON RAILWAY CO., Grand Rapids, Mich.

Electrical Engineer, C. A. Sibert; (Way) Roadmaster, B. Rickerd; Foreman Bridge and Buildings, C. Wilson.

GRAND RAPIDS RAILWAY CO., Grand Rapids, Mich

General Superintendent and Purchasing Agent, J. C. Madigan; Chief Engineer, T. C. Roderick; Master of Construction, D. Campbell; Master Mechanic, D. Lynch; Engineer Power Station, F. Mefford.

GRANITE CITY RAILWAY CO., St. Cloud, Minn.

General Manager and Purchasing Agent, E. E. Clark; Electrical Engineer, Ezra Kuehl.

GRAY'S HARBOR RAILWAY & LIGHT CO., Aberdeen, Wash.

Chief and Electrical Engineer, E. A. Bradner; Chief Engineer Power Station, H. A. Bradner; Master Mechanic, O. Knapp; Roadmaster, D. V. Good.

GREAT FALLS ELECTRIC PROPERTIES — STREET RAILWAY BRANCH, Great Falls, Mont.

Superintendent of Equipment Electric Traction Buildings and Structures, L. M. McAllister; Superintendent of Power Generation and Distribution, C. W. Todd; Track Foreman, R. S. Andrews.

HALIFAX ELECTRIC TRAMWAY CO., LTD., Halifax, N. S.

Manager and Purchasing Agent, J. W. Crosby; General Superintendent and Chief Engineer, P. A. Freeman.

HANOVER & MCSHERRYSTOWN STREET RAILWAY CO., Hanover, Pa.

General Manager and Purchasing Agent, R. E. Manley; Chief Engineer, R. B. McKinnon; Master Mechanic, Leroy Stokes; Roadmaster, Robert Hiltabridle.

HARTFORD & SPRINGFIELD STREET RAILWAY CO., Warehouse-point, Conn.

Superintendent Track Roadway and Overhead Lines, H. K. Greenwood; Superintendent Power and Equipment, F. M. DuBois; Purchasing Agent, Ray W. Reynolds.

HATTIESBURG TRACTION CO., Hattiesburg, Miss.

Secretary and Treasurer, A. B. Paterson; General Manager and Purchasing Agent, C. Z. Stevens.

HELENA LIGHT & RAILWAY CO., Helena, Mont.

Electrical Engineer, C. H. Bernier; Master Mechanic, G. E. Slusher; Engineer Power Station, V. B. D. LaFleur.

HOLYOKE STREET RAILWAY CO., Holyoke, Mass.

Chief Engineer, R. Blanchard; Electrical Engineer, G. L. Chapin; Roadmaster, Thos. Smith.

HONOLULU RAPID TRANSIT & LAND CO., Honolulu, Hawaii.

General Manager and Purchasing Agent, C. G. Ballentyne; Chief Engineer Power Station, Robt. Menaugh; Electrician and Master Mechanic, Geo. F. Wilke; Roadmaster, R. M. Duncan.

HORNELL TRACTION CO., Hornell, N. Y.

General Manager, D. A. Proctor; Superintendent, D. J. Haren.

HOT SPRINGS STREET RAILWAY, Hot Springs, Ark.

Vice-President and Managing Director, Judson H. Boughton; Supervising Engineers and Purchasing Agents, National Light & Power Co., St. Louis; Master Mechanic, F. A. S. Williams; Roadmaster, Chas. Jones.

HOUGHTON COUNTY TRACTION CO., Houghton, Mich.

Electrical Engineer, P. I. Robinson; Chief Engineer, John M. Nelson; Purchasing Agent, W. J. Baird; Engineer Power Station, B. L. Walsh; Master Mechanic, Paul Laechel; Roadmaster. Edw. Pelts.

HOUSTON ELECTRIC CO., Houston, Tex.

Engineer Maintenance of Way, W. M. Archibald; Chief Engineer Power House, J. F. Usener; Engineer Construction, W. V. Burnell; Superintendent of Rolling Stock, V. W. Berry; Master Mechanic, F. J. Bennett; Purchasing Agent, A. T. Kunz.

HUDSON & MANHATTAN RAILROAD CO., New York, N. Y.

Chief Engineer Jersey City Power House, D. Sage; Superintendent Maintenance of Way, C. S. Klumpp; Road Engineer, Leslie Muller; Telephone and Lighting Inspector, E. M. Blake; Superintendent of Car Equipment, P. V. See; General Inspection Foreman, J. W. Hulme; Supervisor of Signals, M. H. Collins; Chief Electrician, L. G. Smith (In charge of Substations); Chief Engineer, J. V. Davies; Purchasing Agent, T. P. Artand.

HUDSON VALLEY RAILWAY CO., Glens Falls, N. Y.

Purchasing Agent, J. W. Sprong; Superintendent of Lines, Geo. W. Davidson; Chief Engineer, Geo. H. Burgess; Roadmaster, T. Crowley; Master Mechanic, J. F. Uffert; Resident Engineer, D. J. Rainville.

HUNTINGTON RAILROAD CO., Huntington, N. Y.

Purchasing Agent, H. B. Hodges; Electrical Superintendent, L. S. Wells; Chief Engineer, J. R. Savage; Real Estate Agent, H. A. Howarth; Insurance Agent, R. H. Newborn; Engineer Maintenance of Way, E. M. Weaver.

HUTCHINSON INTERURBAN RAILWAY CO. (THE), Hutchinson, Kan.

General Manager, Purchasing Agent and Electrical Engineer, W. A. Scothorn; Roadmaster, James Murray.

ILLINOIS TRACTION SYSTEM, Springfield, Ill.

Engineer Maintenance of Way, L. B. Martin; Superintendent of Motive Power and Equipment, J. M. Bosenbury; Chief Operating Engineer, R. C. Carley; Purchasing Agent, H. J. Vance; Superintendent Overhead Lines, J. Leisenring.

INDIANAPOLIS & CINCINNATI TRACTION CO., Indianapolis, Ind.

Chief Engineer Power Station, Samuel Waggoner; Master Mechanic, W. Skipton.

INDIANAPOLIS, COLUMBUS & SOUTHERN TRACTION CO., Columbus, Ind.

General Manager and Purchasing Agent, Alexander Shane; Superintendent Ways and Structures, F. P. Smith; Master Mechanic, W. E. Myers; Electrical Engineer and Engineer Power Station, L. Crater.

INDIANAPOLIS, CRAWFORDSVILLE & DANVILLE ELECTRIC RAILWAY CO., Crawfordsville, Ind.

General Manager and Purchasing Agent, J. N. Spellman; Superintendent and Roadmaster, E. A. Turpin; Engineer Power Station, E. Barr; Master Mechanic, Roy Clark.

INDIANAPOLIS TRACTION & TERMINAL CO., Indianapolis, Ind.

Chief Engineer, Charles Hogate; Civil Engineer, Thomas B. McMath; Superintendent Overhead Construction, Edw. Hayden; Master Mechanic, L. M. Clark.

INTERBOROUGH RAPID TRANSIT CO., New York, N. Y.

Chief Engineer, George H. Pegram; Superintendent Motive Power, H. G. Stott; Superintendent Car Equipment, James S. Doyle; Engineer Car Equipment, Norman Litchfield.

INTERURBAN RAILWAY CO. (THE), Helena, Ark.

General Manager, A. P. Herner.

INTER-URBAN RAILWAY COMPANY, Des Moines, Ia.

Superintendent of Power, J. E. Rolston; Chief Engineer, J. R. Sterling; Roadmaster, Thos. Marlow; Purchasing Agent, F. M. Harris.

INTERURBAN RAILWAY & TERMINAL CO. (THE), Cincinnati, O.

Master Mechanic, F. F. Bruggenuan; Chief Engineer, B. E. Loux; Purchasing Agent and Electrical Engineer, F. H. Talbot; Roadmasters, J. Holt and M. Ayers.

IOWA & ILLINOIS RAILWAY CO., Davenport, Ia.

General Manager, P. P. Crafts; Chief Engineer, J. B. Skiff; Roadmaster, J. Wideman.

IOWA CITY ELECTRIC RAILWAY CO., Iowa City, Ia.

General Manager and Purchasing Agent, J. O. Schulze; Master Mechanic, Edw. Goettsche.

ITHACA STREET RAILWAY CO., Ithaca, N. Y.

General Manager and Chief Engineer, H. A. Clarke; General Superintendent and Purchasing Agent, T. P. Clancy; Engineer Power Station, J. N. Bennett; Master Mechanic, Wm. Brooks; Roadmaster, John Graney.

JACKSON LIGHT & TRACTION CO., Jackson, Miss.

General Manager, Raymond H. Smith; Operating Engineer, Samuel C. Shaffner.

JACKSONVILLE TRACTION CO., Jacksonville, Fla.

Chief Engineer, E. D. Barry; Master Mechanic, A. B. Bowman.

JERSEY CENTRAL TRACTION CO., Keyport, N. J.

Engineer Power Station, John T. Geran; Line Constructor, Chris. Jensen; Master Mechanic, A. A. Churchill; Roadmaster, Thos. Fitzgerald; Superintendent Overhead Line, J. P. Johnson.

JOHNSON CITY TRACTION CORPORATION, Johnson City, Tenn.

General Manager and Purchasing Agent, Amzi Smith, Jr.; Electrical Engineer and Roadmaster, G. C. Sanders; Master Mechanic, H. H. Collins; Chief Engineer, Karl Thornburg.

JOPLIN & PITTSBURG RAILWAY CO., Pittsburg, Kan.

General Manager and Purchasing Agent, W. A. Satterlee; Chief Engineer Power Station, C. E. Knowles; Master Mechanic, M. Miers; Roadmaster, C. R. Ellis.

KANSAS CITY, CLAY COUNTY & ST. JOSEPH RAILWAY CO., Kansas City, Mo.

Master Mechanic, J. N. Spellman.

KANSAS CITY RAILWAY & LIGHT CO., Kansas City, Mo.

Chief Engineer, A. E. Harvey; Electrical Engineer, C. E. Fritts; Master Mechanic, Geo. J. Smith.

KANSAS CITY-WESTERN RAILWAY CO. (THE), Leavenworth, Kan.

Purchasing Agent, J. G. Herrin; Electrical Engineer, John Hull; Roadmaster, E. E. Grabil; Consulting Engineers, Hedrick and Cochrane Engineering Co.

KENTUCKY TRACTION & TERMINAL CO., Lexington, Ky.

Chief Engineer (Way Matters, Buildings and Structures and Heavy Electric Traction), George MacLeod; Electrical Engineer (Power Distribution, Line Equipment), John P. Pope; Superintendent of Production (Power Generation, Power Plant Equipment), H. H. Robertson; Master Mechanic (Shops and Rolling Stock Maintenance), W. G. Stuck.

KEOKUK ELECTRIC CO., Keokuk, Ia.

Manager, A. D. Ayers; Chief Engineer Power Station, N. W. Bowlby.

KEY WEST ELECTRIC CO. (THE), Key West, Fla.

Superintendent of Way, B. L. Grooms; Chief Engineer Power Stations, Anthony Yates; Superintendent of Power Distribution, J. H. Monticino; Master Mechanic, E. D. Loper.

KINGSTON, PORTSMOUTH & CATARAQUI ELECTRIC RAILWAY CO., Kingston, Ont., Canada.

General Superintendent and Purchasing Agent, Hugh C. Nickle.

KNOXVILLE RAILWAY & LIGHT CO., Knoxville, Tenn.

Engineer of Construction, Frank J. Jones; Roadmaster, M. D. Wyrick; Superintendent Power House, James Link; Superintendent Overhead Lines, C. D. Green; Master Mechanic, James M. Kington.

KOKOMO, MARION AND WESTERN TRACTION CO., Kokomo, Ind.

Chief Engineer, R. E. Hollis; Superintendent Maintenance of Way, George H. Losey; Master Mechanic, I. H. Montgomery; Supervisor Overhead, L. W. Turner; Purchasing Agent, R. M. Blackmore; Engineer Power Station, L. Fitzsimmons.

LACKAWANNA & WYOMING VALLEY RAPID TRANSIT CO., Scranton, Pa.

Roadmaster, R. P. Kearney; Electric Line Foreman, G. W. Esslinger; Master Mechanic, A. D. Kimmett; Chief Engineer Power Station, O. D. Havard.

LAKE SHORE ELECTRIC RAILWAY CO., Sandusky, O.

Engineer Maintenance of Way and Structures, A. V. Brown; Superintendent of Motive Power and Cars, Fred Heckler; Roadmaster, Roy Bragdon.

LAREDO ELECTRIC & RAILWAY CO. (THE), Laredo, Tex.

Superintendent and Master Mechanic, Jno. B. Morton; Chief Engineer Power Station, G. F. Bumpers.

LA SALLE COUNTY ELECTRIC RAILROAD CO., Chicago, Ill.

President, G. H. Dodge.

LAS VEGAS TRANSIT CO., Las Vegas, New Mex.

General Manager, W. P. Southard; General Superintendent and Chief Engineer, W. A. Haller.

LAWRENCE RAILWAY & LIGHT CO., Lawrence, Kan.

General Manager, J. T. Skinner.

LEHIGH VALLEY TRANSIT CO., Allentown, Pa.

Superintendent Power Generation, W. H. Bromley; Superintendent Equipment, J. G. Baukat; Superintendent Wires, Geo. Buttrick; Electrical Engineer and Manager, Light and Power Department, A. H. S. Cantlin; Chief Engineer of Way and Structures, W. W. Wysor.

LEWISTOWN & REEDSVILLE ELECTRIC RAILWAY CO. (THE), Lewistown, Pa.

Purchasing Agent, J. I. Quigley; Electrical Engineer, C. E. Gossard; Engineer Power Station, S. H. Snook.

LITTLE ROCK RAILWAY & ELECTRIC CO., Little Rock, Ark.

Engineer Construction, W. H. Lark; Master Mechanic, A. R. Koonce; Chief Engineer Power Station, A. W. Russell; Roadmaster, D. Fitzgibbons.

LONDON AND LAKE ERIE RAILWAY & TRANSPORTATION CO. (THE), London, Ont.

President, H. K. George; Master Mechanic, G. Millar.

LOS ANGELES RAILWAY CORPORATION, Los Angeles, Cal.

Chief Engineer, G. J. Kuhrts; Electrical Engineer, L. O. Lieber; Master Mechanic, E. L. Stephens; Superintendent Electrical Repairs, J. L. Clarke.

LOUISVILLE & SOUTHERN INDIANA TRACTION CO., New Albany, Ind.

General Manager, M. J. Insull; Purchasing Agent, C. H. Dallow.

LOUISVILLE RAILWAY CO., Louisville, Ky.

Purchasing Agent, W. H. McClure; Superintendent of Motive Power, F. H. Miller; Superintendent Construction and Maintenance of Way, T. H. Minary; Assistant Superintendent Construction, Chas. L. Christopher; Master Mechanic, John Zoll; Chief Engineer Power Station, F. L. Ray.

LYNCHBURG TRACTION & LIGHT CO., Lynchburg, Va.

Purchasing Agent, R. D. Apperson; Chief Engineer Power Stations, A. J. Kohler; Master Mechanic, S. H. Cochran.

MACON RAILWAY & LIGHT COMPANY, Macon, Ga.

Chief Engineer Power Generation, L. C. Magraw; Superintendent Construction, M. L. Corbett; Purchasing Agent, R. M. Redding; Chief Engineer Power Station, A. M. Howell; Purchasing Agent, T. D. Massee.

MAHONING & SHENANGO RAILWAY & LIGHT CO., Youngstown, O.

General Superintendent of Railways, G. J. A. Paul; Chief Engineer, L. O. Vesser.

MANCHESTER STREET RAILWAY, Manchester, N. H.

Assistant General Manager, Samuel P. Hunt; Chief Engineer Power Station, L. J. Farrell.

MANILA ELECTRIC RAILROAD & LIGHT CO., Manila, P. I.

General Manager, C. L. Stone; Chief Engineer Power Station, G. H. Blaisdell.

MANITOWOC & NORTHERN TRACTION CO., Manitowoc, Wis.

Manager and Purchasing Agent, Thos. Higgins.

MARQUETTE COUNTY GAS & ELECTRIC CO., Ishpeming, Mich.

Chief Mechanical Engineer, R. S. Wilhelm, Master Mechanic, Robt. Strangberg; Electrician, A. E. Brownell.

MARYLAND ELECTRIC RAILWAYS (THE), Annapolis, Md.

Chief Engineer, D. E. Crouse.

MASON CITY & CLEAR LAKE RAILROAD CO., Mason City, Ia.

Master Mechanic, F. M. Graham, Master Car Builder, G. F. Ward; Chief Engineer, J. H. Lary; Chief Electrician, F. M. Graham; Barn Foreman, D. McPeak.

MASSACHUSETTS NORTHEASTERN STREET RAILWAY CO., Haverhill, Mass.

General Manager and Purchasing Agent, Franklin Woodman; Electrical Engineer, J. S. Whittaker; Superintendent Overhead Lines and Bonding, Wm. S. Mellon; Master Mechanic, R. L. Jones.

MAYSVILLE STREET RAILROAD & TRANSFER CO., Maysville, Ky.

Superintendent, Beecher Holliday.

MEMPHIS STREET RAILWAY CO. (THE), Memphis, Tenn.

Chief Engineer, J. H. Haylow; Electrical Engineer, E. D. Martinez; Engineer Power Station, T. J. Tucker; Master Mechanic, A. D. McWhorter; Roadmaster, T. M. Gorman; Purchasing Agent, R. Meuter.

MENOMINEE & MARINETTE LIGHT & TRACTION CO., Menominee, Mich.

General Manager, Edward Daniell.

MERIDIAN LIGHT & RAILWAY CO., Meridian, Miss.

Master Mechanic, C. N. Holland; Master Car Builder, A. J. Carter; Roadmaster, J. T. Merrill; Chief Steam Engineer, F. L. Bailey; Electrical Superintendent, C. L. McBride.

METROPOLITAN WEST SIDE ELEVATED RAILWAY CO. (THE), Chicago, Ill

Engineer Maintenance of Way, B. J. Fallon; Master Mechanic, H. A. Johnson; Chief Engineer, C. M. Mook; Electrical Engineer, E. J. Blair; Roadmaster, D. Sheehan; Chief Engineer Power House, A. L. Hadin; Purchasing Agent, E. E. Kretschmer.

MEXICO TRAMWAYS CO., City of Mexico, Mex.

Chief Engineer, W. H. Fiske; Master Mechanic, George C. Murray; Purchasing Agent, Geo. J. Troop.

MICHIGAN UNITED TRACTION COMPANY, Jackson, Mich.

Superintendent Maintenance of Way, H. D. Sanderson; Chief Engineer and Electrical Superintendent, F. W. Haak; Superintendent of Equipment, R. C. Taylor; Purchasing Agent, H. K. Sherman; Roadmaster, F. M. Farley.

MIDDLESEX & BOSTON STREET RAILWAY CO., Newtonville, Mass.

Purchasing Agent, F. G. L. Henderson.

MILFORD & UXBRIDGE STREET RAILWAY CO., Milford, Mass.

Chief Engineer Power Station, F. Daniels; Chief Engineer and Master Mechanic, F. Bethel; Engineer Maintenance of Way, H. Rogers.

MILLVILLE TRACTION CO., Millville, N. J.

Master Mechanic and Electrician, Jacob E. Straub; Consulting Engineer (in charge of Power Generation), Charles H. Bigelow.

MILWAUKEE ELECTRIC RAILWAY & LIGHT CO. (THE), Milwaukee, Wis.

Engineer of Way and Structures, R. H. Pinkley; Mechanical Engineer, Rolling Stock, C. H. Cross; Civil Engineering, E. J. Archambault; Engineer of Equipment, W. W. Hunzicker; Engineer of Power Plants, John Anderson; Electrical Engineer, G. G. Post; Mechanical Engineer, (Draughting) O. Smith Peterson; Efficiency Engineer, H. A. Flertzheim; Superintendent of Rolling Stock, H. A. Mullett; Chief Engineer Power Plants, C. A. Cahill.

MILWAUKEE-WESTERN RAILWAY CO., Milwaukee, Wis.

Consulting Engineer, W. D. Chapman; Engineers, C. A. Chapman, Inc.

MINNEAPOLIS, ST. PAUL, ROCHESTER & DUBUQUE ELECTRIC TRACTION CO., Rochester, Minn.

Chief Engineer (in charge of Construction, Way Matters, Buildings and structures), Albert Graber; Superintendent of Motive Power, Geo. O'Rourke; Roadmaster, A. H. Daugherty; Purchasing Agent, F. A. Martin.

MISABA RAILWAY CO., Virginia, Minn.

General Manager, H. S. Newton.

MISSOULA STREET RAILWAY CO., Missoula, Mont.

Engineer of Way, H. L. Bickenback; Superintendent Electrical Department, E. H. Collar; Master Mechanic, Geo. Wilcomb.

MISSOURI & KANSAS INTERURBAN RAILWAY CO., Overland Park, Kan.

Purchasing Agent, E. N. Daniels; General Manager, Thomas Riley.

MOBILE LIGHT & RAILROAD CO., Mobile, Ala.

Master Mechanic, S. M. Coffin; Superintendent of Construction, J. K. Moore; Chief Engineer Power Station, C. Manker.

MONONGAHELA VALLEY TRACTION COMPANY, Fairmont, West Va.

Electrical Engineer, R. L. Kingsland; Superintendent Equipment, E. C. Bowman; Chief Engineer, J. P. Wigginton; Purchasing Agent, A. T. Watson.

MONTEREY RAILWAY, LIGHT & POWER CO., Monterey, N. L., Mexico.

Consulting Engineer, E. Leonarz; Construction Engineeer, F. H. Lancashire; Mechanical Superintendent, C. D. Baxter.

MONTGOMERY LIGHT & TRACTION CO., Montgomery, Ala.

Master Mechanic, (Equipment, Electric Traction and Buildings and Structures), M. J. McAloney; Chief Engineer Power House, J. M. Chumbley; General Manager and Purchasing Agent, L. D. Mathes.

MONTREAL TRAMWAYS CO., Montreal, Que.

Chief Engineer and Superintendent of Construction, J. D. Evans; Superintendent of Power Plants, A. S. Byrd; Superintendent of Rolling Stock, D. E. Blair.

MOOSE JAW ELECTRIC RAILWAY CO. (THE), Moose Jaw, Sask., Can.

Superintendent and Resident Electrical Engineer, A. Hector Dion; Consulting Engineer, John A. McRae.

MORRIS COUNTY TRACTION CO., Morristown, N. J.

Superintendent Electrical and Mechanical Departments, J. McL. Burns; Chief Engineer, J. L. Desch.

MUNCIE & PORTLAND TRACTION CO. (THE), Portland, Ind.

General Manager and Purchasing Agent, E. B. Lincoln.

MUSKEGON TRACTION & LIGHTING CO., Muskegon, Mich.

Purchasing Agent, H. S. Nelson; Electrical Engineer, W. Eyke; Master Mechanic, Chris Dahl; Roadmaster, C. F. Warner.

MUSKOGEE ELECTRIC TRACTION CO., Muskogee, Okla.

Manager and Purchasing Agent, R. D. Long; Master Mechanic, A. G. Corey; Chief Engineer, E. M. Graham.

NAHANT & LYNN STREET RAILWAY CO., Lynn, Mass.

General Manager and Electrical Engineer, Joseph E. Dozier; Master Mechanic, Henry L. Campbell.

NASHVILLE RAILWAY & LIGHT CO., Nashville, Tenn.

Electrical Engineer, H. S. Badger; Engineer Maintenance Way, H. C. Benagh; Chief Engineer Power House, W. G. Cameron; Master Mechanic, Geo. Swint.

NEW ORLEANS RAILWAY & LIGHT CO., New Orleans, La.

Engineer of Way and Structures, L. C. Datz; Superintendent of Power, E. B. McKinney; Superintendent Railway Distribution, V. L. Willoz; Superintendent of Equipment, R. M. O'Brien; Superintendent of Electrical Distribution, F. J. Schwab.

NEWPORT NEWS & OLD POINT RAILWAY & ELECTRIC CO., Hampton, Va.

Chief Engineer, C. D. Porter; Superintendent Power Station, A. E. Stierly; Master Mechanic, E. J. Coleman.

NEW YORK & NORTH SHORE TRACTION CO. (THE), Roslyn, N. Y.

Engineer Maintenance of Way, Harry Tappen; Master Mechanic, C. A. Kinsey.

NEW YORK STATE RAILWAYS, Rochester, N. Y.

Chief Engineer, J. P. Barnes; Engineers Maintenance of Way, D. P. Falconer and E. P. Roundey; Master Mechanic, G. M. Cameron; Electrical Engineer, C. L. Cadle; Purchasing Agent, H. M. Butler.

NEW YORK STATE RAILWAYS, UTICA LINES, Utica, N. Y.

Chief Engineer, J. P. Barnes; Engineer Maintenance of Way, M. J. French.

NORFOLK & BRISTOL STREET RAILWAY CO., Foxboro, Mass.

General Superintendent and Purchasing Agent, F. M. Perry; Master Mechanic, Chas. G. Cleveland; Chief Engineer Power Station, Chas. E. Short.

NORTH CAROLINA PUBLIC SERVICE CO. (THE), Greensboro, N. C.

Master Mechanic, George Jennings.

Construction work for this Company is carried on by W. C. Coler & Co., Engineering Department.

Officers: Vice-President, General Manager and Consulting Engineer, J. P. Clark; Superintendent of Construction, John Nicol.

NORTHAMPTON STREET RAILWAY CO., Northampton, Mass.

General Manager, Louis D. Pellissier; Chief Engineer, A. M. Day; Chief Electrician and Master Mechanic, J. J. Rockett.

NORTHAMPTON TRACTION CO., Easton, Pa.

General Manager, W. V. Hay.

NORTH JERSEY RAPID TRANSIT CO., Paterson, N. J.

Chief Engineer, Geo. Jackson, Jr.

NORTHERN CAMBRIA STREET RAILWAY CO., Patton, Pa.

Superintendent, J. L. McNelis.

NORTHERN ELECTRIC RAILWAY CO., San Francisco, Cal.

Mechanical and Electrical Engineer, J. P. Edwards; Master Mechanic, C. A. Humphreys; Roadmaster, Chas. Horan.

NORTHERN ILLINOIS LIGHT & TRACTION CO., Ottawa, Ill.
General Manager, H. E. Chubbuck.

NORTHERN OHIO TRACTION & LIGHT CO., Akron, O.
Superintendent Motive Power, Wm. H. Roberts; Mechanical and Electrical Engineer, W. E. Salber; Engineer of Building and Structures, G. C. Lathrop; Engineer of Way, E. D. Ecroad; Superintendent of Power Distribution, V. W. Shear.

NORTHERN TEXAS TRACTION CO., Fort Worth, Tex.
Mechanical Engineer, E. L. White; Electrical Engineer, E. E. Nelson.

NORTHWESTERN OHIO RAILWAY & POWER CO., Toledo, Ohio.
General Manager, E. A. Burrill; Master Mechanic, C. C. Woods.

NORTHWESTERN PENNSYLVANIA RAILWAY CO., Meadville, Pa.
General Manager, C. L. Murray; Electrical Engineer, Wm. G. Catherman.

OGDEN RAPID TRANSIT CO., Ogden, Utah.
Master Mechanic, W. E. Read; Chief Engineer, Jos. A. West.

OHIO & SOUTHERN TRACTION CO. (THE), Columbus, O.
Chief Engineer and General Manager, E. C. Schwab.

OHIO ELECTRIC RAILWAY CO. (THE), General Office, Cincinnati, O.
Consulting Engineer, Thomas Elliott; Chief Engineer in charge of Roadway and Construction, Gaylord Thompson; Roadway Engineer, Northern District, Thos. P. Johnson; Roadway Engineer, Eastern and Central Districts, G. B. Darnell; Roadway Engineer, Southern and Western Districts, R. H. Graham; Superintendent of Power Stations, Chas. Iden; Chief Engineer Lindenwald Power Plant, J. E. Ginter; Chief Engineer Medway Power Plant, E. E. Unzicker; Chief Engineer Lima Power Plant, Wm. D. Diehl; Chief Engineer Zanesville Power Plant, I. W. Smith; Chief Engineer Hebron Power Plant, A. L. Swank; Superintendent of Lines Southern and Western Districts, Clint Wallace; Superintendent of Sub-Stations Southern and Western Districts, Geo. C. Shaffer; Superintendent of Lines Eastern and Central Districts, Wm. P. Duffill; Superintendent Lines and Sub-Stations Northern District, J. E. Cochran; Superintendent Light and Power Department, Lima, Ohio, John C. Sweeney; General Master Mechanic, F. J. Foote; Master Mechanic Northern District, F. A. Bundy; Master Mechanic Southern and Western Districts, Jas. Warren; Foreman Newark Shops, Chas. J. Bounds; Foreman Columbus Shops, Ralph Fox.

OHIO RIVER ELECTRIC RAILWAY & POWER CO. (THE), Pomeroy, O.

Electrical Engineer, J. C. Chase; Engineer Power Station, Jas. Greathouse; Roadmaster, R. E. Robson.

OHIO VALLEY ELECTRIC RAILWAY Co., Huntington, W. Va.

Electrical and Chief Engineer, James Fagan; Engineer Power Station, Chas. Lake.

OKLAHOMA RAILWAY Co., Oklahoma City, Okla.

Second Vice-President and General Manager, Geo. W. Knox; Chief Civil Engineer, W. W. Small; Chief Engineer Power Station, L. G. Purtee; Master Mechanic, Chas. W. Day; Roadmaster, P. W. Graham.

OLYMPIA LIGHT & POWER Co., Olympia, Wash.

General Manager, L. B. Faulkner.

OMAHA & COUNCIL BLUFFS STREET RAILWAY Co., Omaha, Neb.

Assistant General Manager, R. A. Leussler; Superintendent Power Station, D. W. Gilbert; Master Mechanic, T. E. Wood.

OMAHA, LINCOLN & BEATRICE RAILWAY Co., Lincoln, Neb.

Master Mechanic, C. C. Pinkerton; Superintendent Way Matters, Patrick Powers; Superintendent Power distribution, L. K. Pettit.

OREGON ELECTRIC RAILWAY Co., Portland, Ore.

Chief Engineer, L. B. Wiskershaw; Electrical Engineer, L. B. Cramer; Superintendent Way and Structures, J. O. Johnson, Jr.; Master Mechanic, G. H. Hopkins; Purchasing Agent, F. A. Bushnell; Superintendent of Motive Power, A. C. Adams.

OTSEGO & HERKIMER RAILROAD Co., Hartwick, N. Y.

Purchasing Agent and Master Mechanic, M. J. Bogardus; Electrical Engineer, C. S. Stanton; Engineer Maintenance of Way, C. S. Lee; Roadmaster, Jas. Feeney.

OTTAWA ELECTRIC RAILWAY Co., Ottawa, Ont.

Superintendent, F. D. Burpee.

OTTUMWA RAILWAY & LIGHT Co., Ottumwa, Iowa.

Engineers, H. M. Byllesby & Company; Engineer Power Station, H. T. Yust; Master Mechanic, F. Weirsmith; Roadmaster, H. Ramsey.

PACIFIC ELECTRIC RAILWAY COMPANY, Los Angeles, Cal.

Chief Engineer, G. E. Pillsbury; Assistant Chief Engineer Maintenance of Way and Structures, E. C. Johnson; Mechanical Engineer Cars, Machinery, etc., F. F. Small; Electrical Engineer Overhead, Power, Sub-Station equipment, etc., S. H. Anderson; Superintendent Telephone, Telegraph and Signals, A. E. Roome; General Purchasing Agent, F. W. Taylor.

PADUCAH TRACTION CO. (THE), Paducah, Ky.

Superintendent of Light, Power and Equipment, F. Cloen; Superintendent of Track and Roadway, J. W. McNeely; Superintendent of Gas and Electric Distribution, C. E. Bell.

PANAMA TRAMWAYS COMPANY, Panama, C. Z.

Consulting Engineer, C. G. Young.

PARIS TRANSIT COMPANY, Paris, Tex.

Local Manager, Jno. A. Porter; Chief Engineer, Geo. E. Moffat.

PARKERSBURG, MARIETTA & INTER-URBAN RAILWAY CO., Parkersburg, W. Va.

Chief Engineer and General Foreman, Maintenance of Way, C. C. Gallaher; Electrician, Geo. Stout.

PEEKSKILL LIGHTING & RAILROAD CO., Ossining, N. Y.

General Manager and Purchasing Agent, Stuart Wilder; Engineer Power Station, C. L. Woods; Roadmaster, C. J. Stillwell; Master Mechanic, Ira Mead.

PENINSULAR RAILWAY CO., San José, Cal.

Engineer, F. U. McPeak; Superintendent of Construction, H. H. Lynch; Purchasing Agent, F. W. Taylor; Electricial Engineer, J. H. Parsons; Master Mechanic, J. Rego; Roadmaster, W. T. Bailey.

PENNSYLVANIA RAILROAD CO. (THE), Philadelphia, Pa.

Vice-President in Charge of Operation, W. W. Atterbury; Vice-President in Charge of Real Estate Purchases and Insurance, W. Heyward Myers; Chief Engineer of Electric Traction, George Gibbs; Assistant Chief Engineer of Electric Traction, E. R. Hill; Master Mechanics, C. B. Keiser and F. G. Grimshaw; Chief Engineer, A. C. Shand; Mechanical Engineer, A. S. Vogt.

PENSACOLA ELECTRIC CO., Pensacola, Fla.

Master Mechanic, E. T. Smith; Roadmaster, R. C. Willoughby; Chief Engineer, Herbert Harley.

PEOPLE'S GAS & ELECTRIC CO., Burlington, Iowa.

Purchasing Agent, D. D. Bentzinger; Electrical Engineer, Chas. E. Castor; Chief Engineer Power Station, Geo. Mills; Master Mechanic, J. Holman; Roadmaster, H. Heinzel.

PEOPLE'S RAILWAY CO. (THE), Dayton, O.

Mechanical Engineer, Thos. F. Synnett; Track Foreman, James Sager; Master Mechanic, Jos. H. Towle.

PEORIA RAILWAY TERMINAL CO., Peoria, Ill.

Roadmaster, Frank Aeillo; Chief Electrician, D. Moran.

PETERBOROUGH RADIAL RAILWAY CO. (THE), Peterborough, Ont.

Electrical Engineer, H. A. Fife; Inspector of Way, J. McCann.

PHILADELPHIA & WEST CHESTER TRACTION CO., Philadelphia, Pa.

Superintendent Maintenance of Way and Structures, C. A. Entrekin; Superintendent Power and Equipment, James E. Pyle; Master Mechanic, E. J. Patterson; Electrical Engineer, W. P. Hall.

PHILADELPHIA & WESTERN RAILWAY CO., Upper Darby, Pa.

Assistant Vice-President, J. L. Adams, in Charge of Operation; Engineer Power Station, H. Y. Watson; Master Mechanic, W. P. Famous; Roadmaster, Frank Curry.

PICTOU COUNTY ELECTRIC CO., LTD., New Glasgow, N. S.

Vice-President, Purchasing Agent, Leonard T. Flaherty; Electrical Engineer, Clarence Wadden; Chief Engineer Power Station, D. Ormiston; Master Mechanic, Wm. Thompson; Roadmaster, Jas. Marshall.

THE PINE BLUFF COMPANY, Pine Bluff, Ark.

Treasurer, B. C. Fowles.

PITTSBURGH & BUTLER STREET RAILWAY CO., Butler, Pa.

Superintendent of Power, Ed. L. Barr; Master Mechanic, John Clark,

PITTSBURGH RAILWAYS CO., Pittsburgh, Pa.

Chief Engineer, F. Uhlenhaut, Jr.; Assistant Engineer, W. C. Boyd; Assistant Engineer, W. W. Handy; Engineer Maintenance of Way, J. M. Larned; Assistant Engineer Maintenance of Way, G. W. Emory; Chief Engineer Power Stations, H. K. Gowdy; Electrical Engineer, J. W. Welsh; Superintendent of Overhead Lines, H. A. Pharo; Superintendent of Equipment, F. R. Phillips; Master Mechanic, John A. Rogan; Assistant Master Mechanic, James C. Keenan.

POINT PLEASANT TRACTION COMPANY, Point Pleasant, N. J.

General Manager and Purchasing Agent, Thos. W. Haldeman; Chief Engineer, R. Major; Master Mechanic, J. Platt; Roadmaster, L. Calligan.

PORTLAND, EUGENE & EASTERN RAILWAY CO., Portland, Ore.

Chief Engineer, R. T. Guppy; General Right of Way Agent, C. E. Woods.

PORTLAND RAILWAY, LIGHT & POWER CO., Portland, Ore.

Vice-President in charge of Purchase of New Equipment, F. I. Fuller; Engineer Maintenance of Way, Thos. Pumfrey; Master Mechanic, F. P. Maize; General Superintendent, Light and Power Department, O. B. Coldwell; Superintendent of Power, Light and Power Department, C. P. Osborne; Operating Engineer, Light and Power Department, R. R. Robley; Superintendent Wires and Conduits, Light and Power Department, H. R. Wakeman; Construction Engineer, Light and Power Department, E. D. Searing; Chief Engineer Steam Plants, W. R. Barley; Superintendent Water Power Plants, Alfred Drill; Hydraulic Engineer, T. W. Sullivan.

PORTLAND RAILROAD CO., Portland, Me.

General Manager and Purchasing Agent, Chas. F. Berry; Chief Engineer Power Station, W. E. Knowlton; Electrical Engineer, J. C. Estes; Roadmaster, F. H. Knight.

PORTO RICO RAILWAY, LIGHT & POWER CO., San Juan, Porto Rico.

Superintendent Lighting Division, H. McR. Jones; Superintendent Power Division, W. H. Lippincott; Superintendent Railroad Division (Steam), W. K. Ackley; Superintendent Railway Division (Electric), J. E. Burns.

PORTSMOUTH STREET RAILROAD & LIGHT CO., Portsmouth, O.

Chief Engineer and Electrical Engineer, Wm. Martin.

POTTSVILLE UNION TRACTION CO., Pottsville, Pa.

Manager, W. B. Rockwell; Master Mechanic, N. M. Lentz; Electrical Superintendent, I. G. Walborn.

POUGHKEEPSIE CITY & WAPPINGERS FALLS ELECTRIC RAILWAY CO., Poughkeepsie, N. Y.

Purchasing Agent, William C. Dalzell, Jr.; Master Mechanic, Homer Tice.

PUBLIC SERVICE COMPANY OF NORTHERN ILLINOIS, Streator, Ill.

Mechanical Engineer, J. L. Hecht; Purchasing Agent, Geo. R. Jones; General Construction Engineers, John G. Learned and Edward Curry.

PUBLIC SERVICE RAILWAY CO., Newark, N. J.

General Manager, R. E. Danforth; Superintendent Maintenance of Way, Martin White; Superintendent of Distribution, E. J. Dunne; Superintendent of Buildings, D. G. Knight; Mechanical Engineer, H. A. Benedict; Engineer Maintenance of Way, Martin Schreiber; Purchasing Agent, J. A. Pearson; Superintendent of Trucking, Daniel Beatty.

PUGET SOUND TRACTION, LIGHT & POWER COMPANY, BELLINGHAM DIVISION, Bellingham, Wash.

Superintendent Railway Department, in charge of Way Matters, Equipment, Heavy Electric Traction, Buildings and Structures, John Hickok, Jr.; Chief Engineer Power Plants, Harvey Titcomb; Superintendent Electric Distribution, R. U. Muffley; Purchasing Agent, E. L. Noyes.

PUGET SOUND TRACTION, LIGHT & POWER CO. SEATTLE DIVISION, Seattle, Wash.

Chief Engineer, Geo. P. James; Office Engineer, G. M. U. Tait; Field Engineer, Carl H. Reeves; Superintendent of Buildings, Joseph Panther, Jr.; Superintendent Light and Power, W. J. Grambs; Operating Superintendent, G. E. Quinan; Superintendent Water Power, John Harrisberger; Superintendent Rolling Stock and Shops, A. D. Campbell; Roadmaster, W. S. Sallee; Mechanical and Electrical Engineer, S. C. Lindsay.

PUEBLA TRAMWAY, LIGHT & POWER CO., Puebla, Pueb., Mex.

General Manager, J. C. Riach.

QUINCY RAILWAY CO., Quincy, Ill.

Superintendent Track and Roadway, J. C. Williams; Chief Engineer Power Plant, W. L. Peters; Superintendent Line Construction, W. C. Miller; Master Mechanic, A. Johnson; Traffic Superintendent (Heavy Electric Traction and Buildings and Structures), J. G. Forsthove.

RAPID TRANSIT RAILWAY CO., Dallas, Tex.

Purchasing Agent, M. P. White; Master Mechanic, W. L. Brown.

RHODE ISLAND CO. (THE), Providence, R. I.

Chief Engineer, H. W. Sanborn; Superintendent Motive Power, William Pestell; Superintendent Equipment, W. D. Wright; Roadmaster, H. F. Purrington; Manager of Purchases and Supplies, H. A. Fabian; Purchasing Agent, J. H. Sanford.

RICHMOND & HENRICO RAILWAY CO., Richmond, Va.

General Superintendent and Chief Engineer, C. Sims Bailey; Electrical Engineer, H. C. Schmidt.

RICHMOND & RAPPAHANNOCK RIVER RAILWAY CO., Richmond, Va.

President, Jos. E. Willard.

RICHMOND LIGHT & RAILROAD CO., New Brighton, N. Y.

Superintendent Railroad Division, T. J. Mullen; Engineer, Geo. G. Fox.

ROANOKE RAILWAY & ELECTRIC CO., Roanoke, Va.

Engineer Roadway, E. H. McConnell; Electrical Engineer, W. T. Clayton; Engineer Power Stations, C. C. Hogshead; Superintendent Railway, W. T. Bush.

ROCKFORD & INTERURBAN RAILWAY CO., Rockford, Ill.

Master Mechanic, L. W. Jacques; Engineer Maintenance of Way, W. S. Hubbard; Electrical Engineer, F. M. Swalm.

ROCK ISLAND SOUTHERN RAILROAD CO., Monmouth, Ill.

General Manager and Purchasing Agent, W. W. McCullough; Electrical Engineer, H. Pine; Chief Engineer Power Station, H. Price.

ROCKLAND, THOMASTON & CAMDEN STREET RAILWAY, Rockland, Me.

Superintendent Electrical Department, W. H. House; Chief Engineer, Chas. E. Gregory.

RUTLAND RAILWAY, LIGHT & POWER CO., Rutland, Vt.

Electrical Engineer, Walter Belding; Master Mechanic, Thomas L. Roach.

PACIFIC GAS & ELECTRIC CO., SACRAMENTO LINES, Sacramento, Cal.

Manager, C. W. McKillip; General Superintendent, W. J. Hullin.

SAGINAW & FLINT RAILWAY, Saginaw, Mich.

Engineer Power Station, B. R. Cushman; Roadmaster, Charles Yeazall; Master Mechanic, A. Feavyear.

SAGINAW-BAY CITY RAILWAY CO., Saginaw, Mich.

Superintendent Power Distribution, F. A. Gavagan; Master Mechanic, L. R. Gaw; Purchasing Agent, Geo. B. Ross.

ST. FRANCOIS COUNTY RAILROAD CO., Farmington, Mo.

Second Vice-President and Managing Director, Judson H. Boughton; Supervising Engineers, National Light and Power Co.; Chief Engineer and Master Mechanic, O. A. Vorpel; Roadmaster, George Halter.

ST. JOSEPH RAILWAY, LIGHT, HEAT & POWER CO., St. Joseph, Mo.

Superintendent of Power, E. J. Billings.

SALT LAKE & OGDEN RAILWAY CO., Salt Lake City, Utah.

Consulting Engineer, L. Wilson; Electrical Engineer, O. R. Payne; Chief Engineer of Structures, E. A. Vail; Roadmaster, M. H. Malwitz; Master Mechanic, Ed. J. Hall; Purchasing Agent, Park Kenner.

SAN ANTONIO TRACTION CO., San Antonio, Texas.

Consulting Engineer, H. C. Abell; Civil and Electrical Engineer, in charge of Track and Overhead Engineering, G. W. Smith; Superintendent Overhead Construction, G. H. Cushman; Superintendent Maintenance of Way, A. M. Courtney; Mechanical Engineer, in charge of Maintenance of Rolling Stock, H. Fink, Jr.

SAN DIEGO ELECTRIC RAILWAY CO., San Diego, Cal.

Purchasing Agent, Geo. Holmes; Chief Engineer, Geo. K. Hellerman; Superintendent Motive Power, Homer MacNutt.

SAN FRANCISCO-OAKLAND TERMINAL RAILWAYS, Oakland, Cal.

Assistant to General Manager and Chief Mechanical and Electrical Engineer, J. Q. Brown; Mechanical and Electrical Engineer, H. L. Griswold; Signal Engineer, H. Wickson; Assistant Mechanical and Electrical Engineer, H. P. Bell; Superintendent Line Department, Thos. Kerin; Superintendent Power Station, F. W. Nelson; Master Mechanic, Geo. St. Pierre; Assistant Master Mechanic, W. P. Jackson; Shop Accountant, E. J. Burns; Assistant to General Manager and Engineer of Way and Structures, Edward M. Boggs; Engineer Maintenance of Way and Buildings, A. W. MacPherson; Assistant Engineers, Maintenance of Way and Buildings, H. B. Murdock, H. O. Demeritt, W. L. Raven; Consulting Engineer Docks and Wharves, Howard C. Holmes; Purchasing Agent, John Wells; Assistant Purchasing Agent, R. L. Dee; Storekeeper, Chas. Christopher.

SAN JOSE & SANTA CLARA COUNTY RAILROAD CO., San José, Cal.

Engineer, F. V. McReak; Superintendent of Construction, H. H. Lynch; Master Mechanic, H. J. Rego.

SAO PAULO TRAMWAY, LIGHT & POWER CO., Sao Paulo, Brazil.

Manager, W. N. Walmsley.

SAVANNAH ELECTRIC CO., Savannah, Ga.

Superintendent of Power, J. B. Anderson; Superintendent of Tracks and Lines, W. B. Purse; Superintendent of Equipment, T. N. Hartin; Purchasing Agent, A. L. P. Smith.

SCHENECTADY RAILWAY CO., Schenectady, N. Y.

Engineer Maintenance of Way, B. Penoyer; Engineer Power Stations, F. Palmatier; Master Mechanic, F. J. Doyle.

SCIOTO VALLEY TRACTION CO. (THE), Columbus O.

Superintendent Way Matters, Equipment, Buildings and Structures, C. Skinner; Electrical Engineer, Power Generation and Distribution, F. W. C. Bailey; Purchasing Agent, A. J. Wolfe; Master Mechanic, Geo. Stiles.

SCRANTON & BINGHAMTON TRACTION CO. (THE), Scranton, Pa.

Chief Engineer, J. C. Dougherty; Superintendent, Purchasing Agent, Chief and Electrical Engineer, R. L. Keohler; Engineer Power Station, Wm. Watkins; Master Mechanic, John McKeand; Roadmaster, H. Wittfoot.

SCRANTON RAILWAY CO., Scranton, Pa.

Engineer Way Matters and Buildings, Maintenance and Construction, H. H. Dartt; Roadmaster, J. J. Boudreau; Master Mechanic, John T. Duffy; Superintendent Lines, A. J. Conlon; Superintendent Power, E. A. Wildt.

SHAWNEE-TECUMSEH TRACTION CO., Shawnee, Okla.

Superintendent, Purchasing Agent and Chief Engineer, O. H. Weddle; Master Mechanic, Asa Bushy; Roadmaster, A. B. Chandler.

SHEBOYGAN RAILWAY & ELECTRIC CO., Sheboygan, Wis.

Superintendent of Light and Power, W. B. Voth; Master Mechanic, W. J. Pagel; Chief Engineer, L. P. Fessenden; Superintendent and Purchasing Agent, Edw. Hammett.

SHEFFIELD CO. (THE), Sheffield, Ala.

Chief Engineer Power Station, J. O. Cosper; Chief Electrician, H. H. Burt; Master Mechanic, Julius J. Frick; Roadmaster, D. P. Azbell.

SHORE LINE ELECTRIC RAILWAY CO. (THE), Saybrook Junction, Conn.

Chief Engineer, J. B. Libby; Electrical Engineer, E. E. Kilburn; Master Mechanic, A. G. Norton.

SHREVEPORT TRACTION CO., Shreveport, La.

President, W. F. Dillon; Vice-President, General Manager and Purchasing Agent, W. A. Sullivan; Engineer Power Stations, E. W. Denham; Master Mechanic, Gus D. Rushing; Roadmaster, J. A. Croyle.

SIOUX CITY SERVICE CO., Sioux City, Ia.

Chief Engineer Power Station, M. W. Lake; Master Mechanic, C. M. Feist; Roadmaster, John Ward; Superintendent Overhead Construction, H. V. Burgess.

SIOUX FALLS TRACTION SYSTEM, Sioux Falls, S. D.

Master Mechanic, Harry Sedgwick.

SOUTHEASTERN OHIO RAILWAY, LIGHT & POWER CO., Zanesville, O.

Manager, Wm. H. Neikirk.

SOUTHERN RAILWAY & LIGHT CO., Natchez, Miss.

General Manager and Purchasing Agent, Frank J. Duffy; Electrical and Chief Engineer, Wm. F. Cox.

SOUTHERN WISCONSIN RAILWAY CO., Madison, Wis.

Master Mechanic and Electrical Engineer, Mat Stumpf; Superintendent Distribution, Wm. Neff; Superintendent Way, Chas. Milbrook.

SOUTHWEST MISSOURI RAILROAD CO., Webb City, Mo.

General Superintendent and Mechanical Engineer, E. J. Pratt.

SPARTANBURG RAILWAY, GAS & ELECTRIC CO., Spartanburg, S. C.

Electrical Engineer, J. D. Maxwell; Engineer Power Station, H. A. Parshall.

SPRINGFIELD CONSOLIDATED RAILWAY CO., Springfield, Ill.

Chief Engineer Power Generation, R. E. Hagenah; Chief Engineer of Power Distribution, H. M. Merrifield; Engineer, Geo. Benzel.

SPRINGFIELD RAILWAY CO. (THE), Springfield, O.

Master Mechanic, E. B. Gunn; Purchasing Agent, W. J. Mulholland; Chief Engineer Power Station, W. R. Nelson; Roadmaster, John Clark.

SPRINGFIELD STREET RAILWAY CO., Springfield, Mass.

Engineer Power and Equipment, P. W. Ripple; Roadmaster, H. M. Flanders; Superintendent of Lines, William Loft; Superintendent of Power Stations, R. G. Tyler; Master Mechanic, G. S. Webb; Purchasing Agent, John F. McCabe.

SPRINGFIELD TRACTION CO., Springfield, Mo.

Master Mechanic, Wm. Weitnauer; Chief Engineer Power House, Wm. Smith; Engineer, B. J. Daly; Chief Engineer (Federal Light & Traction Co.), W. A. Haller.

Springfield, Troy & Piqua Railway Co. (The), Springfield, O.

Chief Engineer, Fred J. Green; Chief Engineer and Electrical Engineer, H. W. Ginevan; Master Mechanic, Howard B. DeWitt.

Sterling-Dixon & Eastern Electric Railway Co., Dixon, Ill.

Vice-President and General Manager, Frank J. Baker.

Sunbury & Susquehanna Railway Co., Sunbury, Pa.

Superintendent, P. H. Gentzel.

Syracuse & Suburban Railroad Co., Syracuse, N. Y.

General Manager, M. Badgero.

Syracuse, Lake Shore & Northern Railroad Co., Syracuse, N. Y.

Chief Engineer Way and Structures, Thos. H. Mather; Third Vice-President and Electrical Engineer, Power Equipment and Buildings, R. A. Dyer, Jr.

Syracuse Rapid Transit Railway Co., Syracuse, N. Y.

Chief Engineer, J. P. Barnes.

Tacoma Railway and Power Co., Tacoma, Wash.

Engineer of Way, W. M. Bosworth; Engineer Power and Equipment, K. C. Schluss.

Tampa Electric Co., Tampa, Fla.

Master Mechanic, George Hudson.

Terre Haute, Indianapolis & Eastern Traction Co., Terre Haute, Ind.

General Superintendent, G. K. Jeffries; General Manager Terre Haute Division, T. F. Grover.

Texarkana Gas & Electric Co., Texarkana, Tex.

General Manager and Purchasing Agent, W. L. Wood, Jr.; Electrical and Mechanical Engineer, George Barnard; Chief Engineer Power Station, A. W. Ball; Master Mechanic, R. S. Goodwin; Roadmaster, J. T. Earhart.

TEXAS TRACTION CO., Dallas, Tex.

Chief Engineer, E. Nevins.

TIDEWATER POWER CO., Winston-Salem, N. C.

Chief Engineer, R. McRae; Superintendent Power Generation, Distribution, Buildings and Structures, Raymond Hunt; Superintendent Traction (Heavy and City), Equipment, R. D. Voshall.

THE TOLEDO & CHICAGO INTERURBAN RAILWAY CO., Kendallville, Ind.

General Superintendent (Heavy Electric Traction and Buildings and Structures), C. J. Munton; Superintendent of Way (Way Matters, Power Distribution), E. L. Vollick; Chief Engineer Power Plants, M. J. Ogden; Master Mechanic, J. Hauff.

THE TOLEDO BOWLING GREEN & SOUTHERN TRACTION CO., Findlay, Ohio.

Superintendent Motive Power, Chas. Kilgour; Chief Engineer Steam Plants, W. G. Nusbaum; Roadmaster, Fred Miller; Master Mechanic, Al. Karns.

THE TOLEDO RAILWAYS & LIGHT CO., Toledo, Ohio.

Superintendent Electrical Department (Power Generation and Power Distribution), W. E. Richards; Engineer Maintenance of Way (Way Matters, Buildings and Structures), A. Swartz; Master Mechanic, C. A. Brown; Manager Railways (Heavy Electric Traction), J. M. Enright.

TOPEKA RAILWAY CO. (THE), Topeka, Kan.

Master Mechanic, S. S. French.

TORONTO RAILWAY CO., Toronto, Ont., Can.

Superintendent Construction and Maintenance, J. G. Smith; Chief Engineer (Power Generation and Distribution), F. G. Clark; Master Car Builder, M. Power; Master Mechanic, W. R. McRae; Architect and Structural Engineer, H. G. Salisbury.

TORONTO SUBURBAN RAILWAY CO., Toronto, Ont., Can.

General Manager and Purchasing Agent, G. C. Royce; Master Mechanic, Jas. Boyd; Roadmaster, D. Kinsman.

TRANS ST. MARY'S TRACTION COMPANY, Sault Ste. Marie, Mich.

Chief Engineer, R. S. McCormick.

TRENTON & MERCER COUNTY TRACTION CORPORATION, Trenton, N. J.

General Superintendent, John C. Thompson.

TRI-CITY RAILWAY COMPANY, Davenport, Iowa.

Master Mechanic, John Sutherland.

TRINIDAD ELECTRIC TRANSMISSION RAILWAY & GAS CO., Trinidad, Colo.

Chief Engineer Federal Light and Traction Co., W. A. Haller; Manager, F. P. Wood.

TRI-STATE RAILWAY & ELECTRIC CO. (THE), E. Liverpool, Ohio.

Engineer Maintenance of Way and Buildings, W. R. Walker; Superintendent Motive Power, E. B. Severs; Master Mechanic, W. T. Croskill.

TUCSON RAPID TRANSIT CO., Tucson, Ariz.

General Manager, Frank E. Russell; Chief Engineer, E. E. Johnson; Chief Engineer and General Superintendent (Federal Light & Traction Co., New York, Controllers), W. A. Haller.

TULSA STREET RAILWAY CO., Tulsa, Okla.

General Manager and Purchasing Agent, C. H. Bosler; Master Mechanic, W. H. Fitzgerald.

TWIN STATE GAS & ELECTRIC CO., Brattleboro, Vt.

Manager, R. L. Fisher; Chief Engineer of Power Station, F. M. Fourtellotte; Line Foreman, D. L. Fisher.

TWIN CITY RAPID TRANSIT CO., Minneapolis, Minn.

Engineer, Power and Equipment, E. H. Scofield; Engineer, Maintenance of Way, Geo. L. Wilson; Master Mechanic, W. J. Smith.

UNION ELECTRIC CO., Dubuque, Ia.

Chief Engineer, G. W. Schmidt; Master Mechanic, J. C. Donovan.

UNION LIGHT & POWER CO., Junction City, Kan.

General Manager, John T. Dalton; Engineer Power Station, F. J. Lochtrog.

UNION STREET RAILWAY CO., New Bedford, Mass.

Master Mechanic, R. B. Bennett.

UNION TRACTION COMPANY OF INDIANA, Anderson, Ind.

Purchasing Agent, S. R. Dunbar; Superintendent of Equipment, R. N. Hemming; Superintendent of Roadway, L. A. Mitchell; Superintendent of Power, G. H. Kelsay.

UNITED ELECTRIC TRAMWAYS OF MONTEVIDEO, Montevideo, Uruguay.

Engineer, (London), Frank Bourne; Consulting Engineers, J. G. White & Co., Ltd.; Resident Engineer, Gerard O. Nevile; Assistant Resident Engineer, Pedro Ingouville; Power House Engineer, W. Scoresby Seaton.

UNITED RAILROADS OF SAN FRANCISCO, San Francisco, Cal.

Engineer Maintenance of Way and Construction, B. P. Legare; Chief Electrician, S. L. Foster; Engineer of Steam Equipment, J. H. Stott; Engineer of Electrical Equipment, W. T. Bivins; Master Mechanic, J. M. Yount; Superintendent Rolling Stock, J. P. Jones; Purchasing Agent, Thomas Finigan.

UNITED RAILWAYS & ELECTRIC COMPANY OF BALTIMORE (THE), Baltimore, Md.

Consulting Engineer, J. M. Hood, Jr.; Chief Engineer, Calvin Whiteley; Engineer of Way, R. L. Chamberlaine; Superintendent Motive Power, August Wolff; Mechanical Assistant Power, F. Batchelder; Electrical Assistant Power, Carroll Thomas; Superintendent Rolling Stock and Shops, A. T. Clark; Assistant Superintendent Rolling Stock and Shops, H. A. Leonhauser.

UNITED RAILWAYS COMPANY OF ST. LOUIS, St. Louis, Mo.

General Manager and Purchasing Agent, Robert McCulloch; Superintendent Power Station, C. A. Hobein; Master Mechanic, M. O'Brien; Roadmaster, William Finn.

UNITED TRACTION CO., Albany, N. Y.

Master Mechanic, J. F. Uffert; Engineer Maintenance of Way, Chas. Brennan; Engineer Power Distribution, H. J. Childs; Superintendent of Power Stations, H. O'Neil.

UTAH LIGHT & RAILWAY CO., Salt Lake City, Utah.

Engineer (Track and Roadway), Buildings and Structures, L. L. Degron; Assistant Engineer, (Track & Roadway), Harry J. Tempest, Jr.; Electrical Engineer, O. A. Honnold; Superintendent Electric Lines and Service, (Distributing), W. M. Scott; Superintendent Power Stations (Generating), C. A. Cohn; Master Mechanic (In Charge of Shops), E. E. Franklin.

VALLEY TRACTION COMPANY, Lemoyne, Pa.

General Track Foreman, E. A. Shissler; Chief Engineer, A. S. Bentz; Electrical Engineer, J. C. Thompson.

VICKSBURG LIGHT & TRACTION CO., Vickburg, Miss.

Electrical Engineer, S. M. Bullis; Chief Engineer, Thos. J. Hunt.

VIRGINIA RAILWAY & POWER COMPANY, Richmond, Va.

Consulting Engineer, George H. Whitfield; Purchasing Agent and Assistant to General Manager and Assistant General Manager, C. C. Johnson.

WALLA WALLA VALLEY RAILWAY CO., Walla Walla, Wash.

Chief Engineer, D. F. McGee; Tax Property and Right of Way Agent, W. H. Galevain; Master Mechanic, P. Fichtner.

WARREN & JAMESTOWN STREET RAILWAY CO., Warren, Pa.

Superintendent and Purchasing Agent, Sam Q. Smith; Electrical Engineer, A. L. Strohm.

WASHINGTON & OLD DOMINION RAILWAY (THE), Washington, D. C.

Chief Engineer, O. W. Bundy; Roadmaster, T. J. Kitchen; Engineer Power Plant, F. Phillips; Electrical Engineer, H. Fitzhugh; Car Barn Foreman, C. P. Markward.

WASHINGTON, BALTIMORE & ANNAPOLIS ELECTRIC RAILROAD COMPANY, Baltimore, Md.

Engineer, Maintenance of Way, Buildings and Structures, E. W. Weinland; Master Mechanic, A. S. Osbelt; Foreman of Sub-Stations, H. T. Connolly.

WASHINGTON RAILWAY & ELECTRIC CO., Washington, D. C.

Engineer of Way, C. S. Kimball; Superintendent of Power, L. E. Sinclair; Purchasing Agent, R. W. Crowell; Master Mechanic, W. A. Wenner.

WASHINGTON-VIRGINIA RAILWAY CO., Washington, D. C.

President, Treasurer, W. H. Lawton; Assistant General Manager and Purchasing Agent, J. B. Hoellman; Chief Engineer, J. H. Stephens; Master Mechanic, D. A. Schum.

WASHINGTON WATER POWER CO. (THE), Spokane, Wash.

General Superintendent Railways (Way Matters, Equipment, Heavy Electric Traction), R. A. Willson; Superintendent Light and Power (Power Generation, Power Distribution), J. B. Fisken; Chief Engineer (Buildings and Structures and General Engineering Matters), C. F. Uhden; Purchasing Agent, V. G. Shinkle.

WATERLOO, CEDAR FALLS & NORTHERN RAILWAY, Waterloo, Iowa.

Chief Engineer, T. E. Rust; Electrical Engineer, Power Generation, G. A. Mills; Electrical Engineer, Power Distribution, G. A. Mills; Superintendent Equipment and Heavy Electric Traction, O. S. Lamb.

WAUPACA ELECTRIC LIGHT & RAILWAY CO., Waupaca, Wis.

General Manager and Purchasing Agent, Irving P. Lord; Engineer Power Station, W. C. Rasmussen; Chief Electrician, B. H. Wilson.

WAYCROSS STREET & SUBURBAN RAILWAY CO., Waycross, Ga.

Superintendent, A. B. Coryell.

WEST CHESTER STREET RAILWAY CO., West Chester, Pa.

Superintendent, Thos. F. Miley.

WESTERN NEW YORK & PENNSYLVANIA TRACTION CO., Olean, N. Y.

Electrical Engineer and Superintendent of Equipment, Wilson K. Page; Engineer Power Station, L. D. Cogswell.

WEST PENN TRACTION & WATER POWER CO., Connellsville, Pa.

Superintendent Power, A. N. Cartwright; Superintendent Plant, L. E. Hankison; Director of Engineering, E. M. Balsinger; Chief Engineer Track and Roadway, J. L. Fritsch; Assistant Chief Engineer Track and Roadway, O. P. Hess; Master Mechanic, Daniel Durie; Purchasing Agent, H. F. Barnard.

WESTSIDE ELECTRIC STREET RAILWAY CO., Charleroi, Pa.

Chief Engineer, All Engineering Departments, Wm. H. Stamm.

WHEELING TRACTION COMPANY, Wheeling, W. Va.

Master Mechanic-Equipment, Frank O'Brien; Superintendent Maintenance of Way and Power Distribution, W. A. Underwood; Superintendent Power Stations, A. G. Mersing.

WILKES-BARRE & HAZLETON RAILROAD CO., Hazleton, Pa.

President, A. Markle; Vice-President and General Manager, C. B. Houck.

WILKES-BARRE RAILWAY CO. (THE), Wilkes-Barre, Pa.

Vice-President, Manager and Purchasing Agent, V. A. Wright; Electrical Engineer, J. Kennedy Mann; Chief Engineer, Power Station, Wm. H. Wheaton; Engineer Maintenance of Way, Edwin A. Hoffman; Assistant Master Mechanic, Edston F. Reese; Superintendent Track Bonding, David Lloyd Swank.

WILLAPA HARBOR RAILWAY COMPANY, Raymond, Wash.

Manager, R. L. Fisher.

WILLIAMSPORT PASSENGER RAILWAY CO., Williamsport, Pa.

Chief Engineer, S. D. Flaugh; Master Mechanic, C. B. Easty; Supervisor of Track, H. M. Colton.

WILMINGTON AND PHILADELPHIA TRACTION CO., Wilmington, Del.

Master Mechanic (in Charge of Equipment and Buildings and Structures), Jacob W. Gerke; Chief Engineer, Power Stations and Power Distribution, C. M. Cooper; General Manager, Way Matters, Etc., Wm. A. Heindle.

WINDSOR, ESSEX & LAKE SHORE RAPID RAILWAY CO., Kingsville, Ont., Canada.

General Manager, Purchasing Agent, A. Eastman; Chief Engineer Power Station, W. W. Chisholm.

WINNIPEG ELECTRIC RAILWAY CO., Winnipeg, Manitoba.

General Manager and Chief Engineer, W. Phillips; Purchasing Agent, J. S. MacKenzie.

WINONA RAILWAY & LIGHT CO., Winona, Minn.

Superintendent Power Distribution, J. B. Rogers; Superintendent Way Matters, W. G. Lyons; Chief Engineer Power Generation, E. H. Kirchner.

WISCONSIN PUBLIC SERVICE COMPANY, Green Bay, Wis.

Superintendent of Electrical Department, C. R. Phenicie; Superintendent of Railway Department, A. T. Bushong; Master Mechanic, J. Jossart; Chief Electrician, Chas. Hasseler; Chief Engineer, E. A. Blodgett; Purchasing Agent, L. O. Landaas; Civil Engineer, C. E. Ewing.

WISCONSIN TRACTION, LIGHT, HEAT & POWER CO., Appleton, Wis.

General Manager, John I. Beggs.

WOODLAWN & SOUTHERN STREET RAILWAY CO., Pittsburgh, Pa.

Assistant Secretary, John L. Moore.

WORCESTER CONSOLIDATED STREET RAILWAY CO., Worcester, Mass.

Superintendent of Lines, C. H. Briggs; Superintendent of Tracks, F. A. Wilkinson; Superintendent of Power Stations, F. M. Finlayson; Master Mechanic, A. J. McPherson; Purchasing Agent, J. F. McCabe.

YAKIMA VALLEY TRANSPORTATION CO., North Yakima, Wash.

Division Engineer of Way Matters, W. C. Marion; Division Engineer of Buildings and Structures and Heavy Electric Traction, W. C. Marion; Electrical Engineer (Power Generation, Distribution and Equipment), Max Vestal.

YORK RAILWAYS COMPANY, York, Pa.

Vice-President and Chief Engineer, L. C. Mayer; Superintendent of Light, Heat and Power, W. H. Long; Superintendent of Transportation, J. E. Wayne; Master Mechanic, E. L. Greene; Purchasing Agent, E. A. Barnitz.

MEMBERS (INDIVIDUAL)

(Arranged According to States)

ALABAMA

MOBILE:

Coffin, S. M., Master Mechanic, Mobile Light & Railroad Co., P. O. Box 823.

ARKANSAS

FORT SMITH:

Chynoweth, Geo. W., Master Mechanic, Fort Smith Light & Traction Co.

LITTLE ROCK:

Koonce, A. R., Master Mechanic, Little Rock Railway & Electric Co.

GREENLAND:

Thornbery, C. H., Engineer.

ARIZONA

JEROME:

Roberts, T. C., The United Verde Copper Co.

CALIFORNIA

BERKELEY:

Keiffer, S. E., Director of Engineering, San Francisco-Oakland Terminal Railways, 78 The Uplands.

LOS ANGELES:

Arlin, A. W., Salesman, General Electric Co., Delta Building.

Clarke, J. L., Superintendent, Electric Repairs, Los Angeles Railway Corporation.

Keese, S. J., Manager, Los Angeles Office, Westinghouse Electric & Manufacturing Co.

Kuhrts, G. J., Chief Engineer, Los Angeles Railway Corporation.

Stephens, Edw. L., Master Mechanic, Los Angeles Railway Corporation.

OAKLAND:

Bell, H. P., Assistant Signal Superintendent, San Francisco-Oakland Terminal Railways, 582 28th Street.

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Brown, J. Q., Assistant to General Manager, San Francisco-Oakland Terminal Railways, 313 Syndicate Building.

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Macpherson, A. W., Engineer, San Francisco-Oakland Terminal Railways, 5645 Oak Grove Ave.

Perrin, L. M., Signal Superintendent, San Francisco-Oakland Terminal Railways, 5443 Locksley Avenue.

St. Pierre, Geo., Master Mechanic, San Francisco-Oakland Terminal Railways, 697 25th Street.

Wells, John, Purchasing Agent, San Francisco-Oakland Terminal Railways, 315 Syndicate Building.

RICHMOND:

Robertson, C. H., Superintendent, East Shore & Suburban Railway Co.

SAN DIEGO:

Holmes, Geo., Purchasing Agent, San Diego Southern Railway Co.

Mac Nutt, Homer, Mechanical Engineer, San Diego Electric Railway Co., 1055 21st Street.

SAN FRANCISCO:

Addison, Dr. T. A., General Electric Co.

Banks, Carl C., Maryland Steel Co., Pennsylvania Steel Co.

Bibbins, J. R., Engineer, 1308 Hewes Building.

Bivins, W. T., Chief Engineer, Motive Power, United Railroads of San Francisco.

Bodler, F. F., Manager, Eccles & Smith Co.

Bowden, R. A., Great Western Power Co.

Briggs, W. W., Assistant Sales Manager, Westinghouse Electric & Manufacturing Co.

Clark, H. S., Vice-President, Westinghouse Electric & Manufacturing Co., Pacific Coast Branch, 889 Pacific Building.

Clapp, Harold W., Electrical Engineer, Southern Pacific Co., Flood Building.

Colby, S. K., Pierson Roeding Co.

Conn, C. F., 310 Sansome Street.

Corbin, M. M., Special Agent, General Electric Co.

SAN FRANCISCO — *Continued:*

Foster, S. L., Chief Electrician, United Railroads of San Francisco.

Green, H. B., Agent, Pennsylvania Steel Co., 1505 Chronicle Building.

Heynemann, L., Manager, Pacific Coast Branch, Goldschmidt Thermit Co., 434 Folsom Street.

Jones, J. P., Superintendent Rolling Stock, United Railroads of San Francisco.

Kirker, G. B., Westinghouse Electric & Manufacturing Co.

Parsons, E. T., Sherwin Williams Co., 54 2d Street.

Richards, F. C., The J. G. Brill Co.

Russell, H. A., Manager, Sales Department, General Electric Co.

Thomson, A. V., Railway Sales Agent, General Electric Co., Rialto Building.

Yount, J. M., Master Mechanic, United Railroads of San Francisco.

STANFORD UNIVERSITY:

Ryan, H. J., Professor of Electrical Engineering, Leland Stanford University.

VALLEJO:

Lynn, W. A., P. O. Box 407.

COLORADO

DENVER:

Bodfish, L. E., Car House Foreman, Denver City Tramway Co., 3256 Hayward Place.

Burtis, W. B., Draughtsman, Denver City Tramway Co., 760 Tramway Building.

Casey, W. E., Chief Electrician, Denver City Tramway Co., 3203 Arafahoe Street.

Chilberg, J., Manager, Sales, The Colorado Fuel & Iron Co.

Cowan, H. W., Chief Engineer, The Denver & Interurban Railroad Co., 801 Copper Building.

Crites, W. B., Stenographer, Denver City Tramway Co., 455 South Clarkson Street.

Dake, T. F., Superintendent Wood Construction, Denver City Tramway Co., 844 Lincoln Street.

Dolezal, Geo. W., Shop Foreman, Denver City Tramway Co., 371 South Washington Street.

Ehnbom, Emil, Engineer, The Denver City Tramway Co.

Evans, A. M., Engineering Department, Denver City Tramway Co.

DENVER — *Continued:*

Ferguson, J. S., Griffin Wheel Co.

Fler, J. R., Car House Foreman, Denver City Tramway Co., 828 25th Avenue, East.

Fligg, H. C., Draughtsman, Denver City Tramway Co., care of P. House, 14th and Platte Streets.

Glaze, H. C., General Electric Co.

Heddendahl, T. A., Westinghouse Air Brake Co., 512 Tramway Building.

Huey, R. E. P., Foreman, Denver & Interurban Railway Co., 2707 Douglas Place.

Longstrom, F., Car House Foreman, Denver City Tramway Co., 673 South Lincoln Street.

McAloney, W. H., Superintendent Rolling Stock, Denver City Tramway Co.

Matthews, W. G., Superintendent Overhead Lines, The Denver City Tramway Co.

Messner, John, Foreman, Denver City Tramway Co., 3120 Race Street.

Metzger, W. C., Foreman Armature Room, Denver City Tramway Co., 1034 South Washington Street.

Morse, O. P., General Foreman Light Department, Denver City Tramway Co.

Strasser, J. C., Armature Winder, Denver City Tramway Co., 1822 South Sherman.

Sullivan, D., Foreman Construction Shop, Denver City Tramway Co., 1229 14th Street.

Toll, R. W., Assistant Engineer, The Denever City Tramway Co., 700 Tramway Building.

Van Buskirk, H. C., Superintendent Motive Power, The Denver & Interurban Railroad Co., 801 Cooper Building.

Ward, W. H., Car House Foreman, Denver City Tramway Co., 1745 South Lincoln Street.

Wastfield, W. D., Field Engineer, The Denver City Tramway Co., Tramway Building.

Welborn, J. F., President, Colorado Fuel & Iron Co.

The Western Pole & Lumber Co.

Woeber, R. L., 79 Logan Street.

Young, A. T., care of Hamilton National Bank, 17th and Champa Streets.

ENGLEWOOD:

Strong, David, Mechanical Department, Denver City Tramway Co., 3795 South Gallepayo.

FORT COLLINS:

De Lay, F. A., Professor Electrical Engineering, Colorado State Agricultural College.

FORT COLLINS — *Continued:*

Lory, C. A., Professor of Physics and Electrical Engineering, Colorado State Agricultural College.

Rankin, F. J., Instructor Electrical Engineering, Colorado Agricultural Collage.

PLACERVILLE:

Hequembourg, K. D.

CONNECTICUT

ANSONIA:

Sherwood, Frank H., American Brass Co.

BRIDGEPORT:

Atwater, Fred, Treasurer, Columbia Nut & Bolt Co.

Brown, Wylie, Bridgeport Brass Co.

Dee, W. V., General Sales Manager, The G. Drouve Co.

Eipper, John E., Columbia Nut & Bolt Co.

BRISTOL:

O'Neil, James A.

HARTFORD:

Blanchard, A., Superintendent Shops, The Connecticut Co., 53 Vernon Street.

Gailor, C. F., Roadmaster, The Connecticut Co.

NEW BRITAIN:

Hoadley, H. G., President and Treasurer, Waterbury Tool Co.

NEW HAVEN:

Amadon, F. W., Assistant Engineer, The Connecticut Co., 308 Railroad Building.

Bates, Harold, Assistant Engineer, The Connecticut Co., 308 Railroad Building.

Bigelow, Frank L., President, The Bigelow Co.

Cooley, E. S., Superintendent Power Plants, The Connecticut Co.

Dunham, Wm. R., Jr., Assistant Engineer, The Connecticut Co.

Harte, Charles R., Assistant Engineer, New York, New Haven Haven & Hartford Railroad Co., 308 Railroad Building.

Kellas, James, Assistant Engineer, The Connecticut Co., 308 Railroad Building.

Kennedy, F. B., Recording Register & Fare Box Co.

Miller, D. S., Electrical Engineer, The Connecticut Co.

Murray, William S., Electrical Engineer, New York, New Haven & Hartford Railroad Co.

Reynolds, H. H., Inspector Stores, The Connecticut Co., Care of General Stores Department.

NEW HAVEN — *Continued:*

Sigourney, W. H., Sales Agent, General Electric Co.
Webster, E. C., Engineer of Way, The Connecticut Co.
Yates, De Forrest, Recording Register & Fare Box Co.

STAMFORD:

Borie, Renshaw, 266 Atlantic Street.

THOMPSON:

Du Bois, F. M., Master Mechanic, Hartford & Springfield Street Railway Co.

DELAWARE

WILMINGTON:

Lobdell, W. W., President, Lobdell Car Wheel Co.

DISTRICT OF COLUMBIA

WASHINGTON:

Brown, L., Chief Lineman, Washington Railway & Electric Co., 3344 Prosepect Avenue.
Derene, Geo. W., Roadmaster, Washington Railway & Electric Co., 1112 B Street, N. E.
Gormley, H. S., Assistant Engineer, Washington Railway & Electric Co.
Harper, J. W., Master Mechanic, Capital Traction Co.
Hanna, J. H., Chief Engineer, Capital Traction Co.
Jackson, H., Superintendent of Construction, Washington Railway & Electric Co., 14th & E. Capital Streets.
Johnston, L. L., Draughtsman, Washington Railway & Electric Co., 14th & E. Capital Streets.
Kimball, C. S., Engineer Maintenance of Way, Washington Railway & Electric Co.
Phillips, R. H., Secretary & Manager, Kensington Railway Co. of Maryland.
Schroeder, G. G., Engineer, International Elevated Railway Co., 1114 H Street., N. W.
Wenner, W. A., Master Mechanic, Washington Railway & Electric Co., 2411 P Street., N. W.

GEORGIA

ATLANTA:

Coolidge, F. H., American Brake Shoe & Foundry Co.
Ginn, E. H., General Electric Co.
Kingston, W. W., Lorain Steel Co.
McWhorter, W. A., 402 Forsyth Building.
Morton, G. L., Galena Signal Oil Co., 403 Forsyth Building.

ATLANTA — *Continued:*

Porter, H. K., U. S. Metal & Manufacturing Co.
Smaw, W. H., Purchasing Agent, Georgia Railway & Electric Co.
Turner, S. G., Assistant Secretary & Manager, Atlanta Car Wheel & Manufacturing Co.
Watkins, S. C., Sales Agent, Atlanta Car Wheel & Manufacturing Co.
Watts, G. E., Electric Service Supplies Co.
Williams, R. W., Westinghouse Traction Brake Co.
Willis, Geo. E., District Sales Agent, Ohio Brass Co., 456 Peachtree Street.

CHATTAHOOCHEE:

Thomas, G. H., Whittier Mills Co.

ILLINOIS

ALTON:

Macy, O. C., Superintendent, East St. Louis & Suburban Railway Co., Alton Lines.

AURORA:

Bales, J. E., Lyon Metallic Manufacturing Co.
Perry, C. B., Lyon Metallic Manufacturing Co.
Van Stone, F. A., Lyon Metallic Manufacturing Co.
Waters, B. L., Lyon Metallic Manufacturing Co.
Waters, Frank S., Lyon Metallic Manufacturing Co.
Waters, R. T., Lyon Metallic Manufacturing Co.
Worley, John, Jr., Lyon Metallic Manufacturing Co.

CHICAGO:

Adam, R. S., G. Drouve Co.
Allen, E. W., General Electric Co.
Allen, G. F., Railway Materials Co.
Allen, J. Drew, Chicago Sales Office, Maryland Steel Co., Pennsylvania Steel Co.
Andresen, A. C., Chicago Pneumatic Tool Co.
Andresen, A. M., Chicago Pneumatic Tool Co.
Arlein, E. J., W. H. Coe Manufacturing Co.
Armbrust, C. W., Love Brake Shoe Co.
Arnold, C. N., Minerallac Electric Co.
Atkin, G. H., Electric Storage Battery.
Atkin, W. Y., American Electrical Works.
Atkins, James, Jr., American Association of Creosoted Wood Paving Manufacturers.
Baker, C. M., Murphy Varnish Co.
Baker, R. N., General Electric Co.
Barden, G. A., Chicago Pneumatic Tool Co.
Barron, A. E., Templeton-Kenly Co.

CHICAGO — *Continued:*

Barrows, Allan S., Pantasote Company.
Bartholomew, W. S., District Manager, Westinghouse Traction Brake Co., 1545 Railway Exchange Building.
Barton, B. S., The G. Drouve Co.
Baur, H. J., Johnson Coin Counting Machine Co.
Baylies, F. N., Aluminum Co. of America.
Beard, W. K., Electric Railway Journal.
Beattys, W. H., Jr., National Brake & Electric Co.
Belknap, R. E., Sales Agent, The Pennsylvania Steel Co., Western Union Building.
Benedict, J. T., Boss Nut Co.
Benham, John, Vice-President, International Register Co., 631 W. Jackson Boulevard.
Bennett, William A., Griffin Wheel Co.
Benson, Fred T., General Electric Co.
Bentley, W. H., Standard Steel Works.
Berg, Max A., Secretary, Electric Service Supplies Co.
Berger, E. F., The Midvale Steel Co.
Biddison, C. T., McGuire Cummings Manufacturing Co.
Bigelow, Geo. S., Chicago Varnish Co.
Birdsall, C. H., President, Johnson Coin Counting Machine Co.
Bischoff, W. E., Western Electric Co.
Bishop, T. M., Consolidated Car Heating Co.
Blatchford, T. W., Spencer Otis Co.
Boon, C. J., American Steel & Wire Co.
Bower, J. G., Hale & Kilburn Co.
Boyce, W. S., The Rail Joint Co.
Brown, H. L., Electric Traction.
Bryant, W. B., Westinghouse Air Brake Co.
Buchanan, J. L., General Electric Co.
Buckman, R. K., Jr., Chicago Varnish Co.
Buell, J. W., General Electric Co.
Burchard, M. H., Westinghouse Air Brake Co.
Burdett, J. B., President, Burdett-Rowntree Manufacturing Co., 515 S. Laflin Street.
Burke, Albert G., Green Engineering Co.
Busch, J. W., Westinghouse Electric & Manufacturing Co.
Bushnell, B. E., 521 South Wabash Avenue.
Butler, W. P., Johnson Coin Counting Machine Co.
Byers, J. J., National Malleable Castings Co.
Cameron, B. F., Duplex Metals Co.
Carpender, M. C., Consolidated Car Heating Co.
Carr, B. M., American Car & Foundry Co.
Carr, R. F., President, Dearborn Drug & Chemical Works, McCormick Building.

CHICAGO — *Continued:*

Carroll, W. P., National Lead Co.
Casgrain, George D., Griffin Wheel Co.
Champion, S. F., Jr., Champion Recording Machine Co.
Childs, T. M., Westinghouse Electric & Manufacturing Co.
Clock, W. I., Crerar Adams & Co.
Coates, C. B., Manager Electrical Department, Chicago Pneumatic Tool Co., 1010 Fisher Building.
Colman, W. H., General Electric Co.
Collins, J. W., American Steel & Wire Co.
Conn, M., Loraine Smelting & Refining Co.
Conkling, F. G., American Steel & Wire Co.
Conover, A. B., Treasurer and Manager, John A. Roebling's Sons Co.
Cook, A. S., Dearborn Drug & Chemical Co.
Cooke, D. I., Secretary, Vacuum Car Ventilating Co., 561 West Monroe Street.
Craig, R. H., Galena Signal Oil Co.
Crane, Geo. B., A. & J. M. Anderson Manufacturing Co.
Crawford, L. C., General Electric Co.
Creer, H. E., McCord Manufacturing Co.
Cummings, John J., McGuire Cummings Manufacturing Co.
Currie, W. I., The Dalton Adding Machine Co.
Daley, Fred A., The Under-Feed Stoker Co., 204 Dearborn Street.
Darlington, F. W., Consulting Engineer, Trunk Line Electrification, 4937 Kenmore Avenue.
Davidson, L. H., Secretary, Board of Supervising Engineers, 105 South La Salle Street.
Davis, J. F., Western Electric Co.
Decampi, E. A., Sales Manager Metal Department, National Lead Co.
de Jong, C. V., Scientific Railway Appliances.
Dewey, L. R., American Brake Shoe & Foundry Co.
Dickinson, W. H., The Railway Materials Co.
Dodge, G. H., General Western Sales Agent, Taylor Electric Truck Co.
Delaney, A. J., American Brake Shoe & Foundry Co.
Denneen, R. J., Ohio Brass Co.
Denny, S. F., Home Rubber Co.
DeWolfe, H. L., The Chapman Valve Manufacturing Co.
Dickerman, H. E., Chisholm & Moore Manufacturing Co.
Dodson, C. F., Baldwin Locomotive Works.
Dorticos, C., General Electric Co.
Dougall, G. F., General Electric Co.
Douglas, G. E., Blocki-Brennan Refining Co.

CHICAGO — *Continued:*

Douglass, C. C., General Elecric Co.
Drake, Francis E., Drake Railway Automotrice Co.
Drum, A. L. & Co., 624 American Trust Building.
Dugan, Reuben A., Scullin-Gallagher Iron & Steel Co.
Dunham, F. S., The Kennicott Co.
Eardlrey, J. C., Salesman, The Chapman Valve Manufacturing Co.
Earl, M. S., Electric Service Supplies Co.
Eddy, Melford B., American Mason Safety Tread Co.
Eggart, C. A., Consolidated Car Heating Co.
Egolg, Fred M., The Curtain Supply Co.
Emery, Plato G., Railway Supply & Curtain Co.
Evans, H. S., The Buda Co.
Evans, Dr. W. A., Vacuum Car Ventilator Co.
Evans, W. H., Edgar Allen Manganese Steel Co., McCormick Building.
Ewing, C. C., Electric Service Supplies Co.
Fagin, Walter M., The Crouse Hinds Co.
Farmer, C. C., Westinghouse Traction Brake Co.
Field, W. J., Electric Traction.
Fisher, R. B., The Buda Co.
Fisher, W. H., Berry Brothers, Ltd.
Flanagan, M. A., The Thiel Detective Service Co.
Fleming, Harvey B., Vice-President Chicago City Railway Co., 1600 First National Bank Building.
Flinn, Frank B., Griffin Wheel Co.
Folsom, E. C., Railway Material Co.
Fondersmith, E. M., Duplex Metals Co.
Fonger, R. V., Fonger Fender Co.
Fonger, W., Fonger Fender Co.
Forman, Paris R., Mechanical Engineer, Burdett-Rowntree Manufacturing Co., 515 Laflin Street.
Forsyth Brothers Co., 31 East Indiana Street.
Forsyth, G. H., Forsyth Brothers Co.
Forsyth, W. H., General Manager, Curtain Supply Co.
Foster, J. W., Nelite Works of General Electric Co.
Franklin, T. U., Indianapolis Brass Co.
Frantz, H. M., Manager Electric Department, H. W. Johns-Manville Co., 322 North Michigan Avenue.
French, C. M., General Manager, The Thiel Detective Service Co.
Friday, C. B., Carnegie Steel Co.
Fry, Emmet M., General Superintendent, North American Railway Construction Co., 1320 Monadnock Building.
Garbutt, H. L., Westinghouse Electric & Manufacturing Co.

CHICAGO — *Continued:*

Garrison, C. W., Simmons-Boardman Publishing Co.
Gaylord, T. P., Westinghouse Electric & Manufacturing Co.
Getts, F. E., General Electric Co.
Giblin, John T., McGuire-Cummings Manufacturing Co.
Glenn, W. D., Westinghouse National Brake & Electric Co. and Westinghouse Traction Brake Co.
Goble, A. S., Standard Steel Works.
Gonden, H. J., Public Service Publishing Co.
Gorder, B. F., Love Brake Shoe Co.
Gordon, F. L., Western Sales Manager, American Brake Shoe & Foundry Co.
Gould, L. E., Western Editor Electric Railway Journal.
Gowing, J. P., Pratt & Lambert.
Graber, W. A., Walinger Co.
Gray, A. A., General Manager, Electrical Review Publishing Co.
Green, Herbert, Vice-President, Burton W. Mudge Co., People's Gas Building.
Green, Russell, E., Standard Underground Cable Co., Rookery Building.
Griffin, Geo. F., Vice-President, Griffin Wheel Co., 600 Western Union Building.
Gundrum, F. N., Jr., Chicago Varnish Co.
Haas, E. M., Electric Railway Journal.
Hall, N. P., Electric Service Supplies Co.
Halla, P. J., Secretary Protection Mutual Fire Insurance Co., 20 West Jackson Boulevard.
Ham, J. E., Valentine & Co.
Hamer, W. D., Electric Service Supplies Co.
Hamill, L., The Buda Co.
Hamlin, E. W., Western Electric Co.
Hammond, A. L., Spencer Otis Co.
Hammond, E. H., Western Agent, American Electrical Works, 112 West Adams Street.
Hammond, W. S., Jr., Consolidated Car Heating Co.
Harkins, J. W., Dearborn Drug & Chemical Co.
Hart, H. H., Spencer Otis Co.
Harthauer, August W. L., McCord Manufacturing Co.
Hasinbiller, O. W., Engineering Inspector, Board of Supervising Engineers, 105 South La Salle Street.
Hazelhurst, A., Standard Steel Works.
Henderson, A. F., W. R. Garton Co.
Henkle, Thos. H., Electric Service Supplies Co.
Hennessy, J. F., Chicago Sales Office, Pennsylvania Steel Co. and Maryland Steel Co.

CHICAGO — *Continued:*

Hertzog, R. R., The Whitmore Manufacturing Co.
Hiatt, H. I., The National Malleable Castings Co.
Hincher, W. W., A. & J. M. Anderson Manufacturing Co.
Hickey, F. S., Dearborn Drug & Chemical Co.
Hodgkins, R. T., Yale & Towne Manufacturing Co.
Hoffman, J. K., Hale & Kilburn Co.
Holladay, L. L., 224 West Illinois Street.
Holloway, H. C., The Rail Joint Co.
Humes, W. S., Transportation Utilities Co.
Hunt, Robert W. Co., Consulting Engineers, 1121 Rookery Building.
Hunt, Wm. M., Green Engineering Co.
Hunt, W. P., The Buda Co.
Hunter, D., Jr., The Under Feed Stoker Co. of America.
Hunter, R. W., Poole Bros.
Ives, C. A., Salesman, General Electric Co.
Jackson, D. C. & W. B., Consulting Engineers, Harris Trust Building.
Johnson, H. A., Master Mechanic, Metropolitan West Side Elevated Co., 3572 West Congress Street.
Johnstone, H. C., Representative, Midvale Steel Co., 841 Railway Exchange.
Jameson, F. H., Electric Service Supplies Co.
Jenks, A. P., General Electric Co.
Johnson, B. A., American Brake Shoe & Foundry Co.
Johnson, H. H., Electric Service Supplies Co.
Johnson, F. E., Ohio Brass Co.
Johnson, J. M., Johnson Coin Counting Machine Co.
Johnson, Oscar, Scientific Railway Appliances.
Jones, F. H., Assistant Resident Manager, General Railway Signal Co., 1248 People's Gas Building.
Junkersfield, Peter, 120 West Adams Street.
Kadish, R. B., New Tone System Co.
Keegan, Harry F., Tool Steel Gear & Pinion Co.
Keily, W. E., McGraw Publishing Co.
Kelker, R. F., Principal Assistant Engineer, Board of Supervising Engineers, Chicago Traction, 105 South La Salle St.
Kenfield, H. J., President, Kenfield-Fairchild Publishing Co.
Kiek, J. A., Western Electric Co.
King, Henry C., American Mason Safety Tread Co.
Kirschke, M. T., Jr., McGuire-Cummings Manufacturing Co.
Kittle, E. B., Vice-President, Vacuum Car Ventilating Co.
Klineschmidt, R. J., Yale & Towne Manufacturing Co.
Knickerbocker, C. K., Sales Agent, Griffin Wheel Co., 600 Western Union Building.

CHICAGO — *Continued:*

Knight, C. S., Jr., American Steel & Wire Co.
Landreth, J. P., Garlock Packing Co.
Lang, E. C., Heywood Brothers & Wakefield Co.
Lange, H. O., Ferguson Lange Foundry Co.
LeBeau, E. A., Chicago Railway Equipment Co.
Lewis, E., W. R. Garton Co.
Libkeman, Wm. A., Sales Agent, Standard Motor Truck Co., Fisher Building.
Lindgren Carl O., Rand McNally Co.
Littlefield, A. S., President, North American Railway Construction Co., 1320 Monadnock Building.
Lotz, Alfred, The Under Feed Stoker Co. of America.
Lubersky, I., Hale & Kilburn Co.
McClellan, B. S., McCord Manufacturing Co.
McCormick, C., American Car & Foundry Co.
McDonald, H. H., Lorin Steel Co.
MacDonald, J. W., Field Engineer, Board of Supervising Engineers, Chicago Traction, 105 South La Salle Street.
McDowell, W. J., General Vehicle Co.
McElroy, J. F., Consolidated Car Heating Co.
McGinn, Howard J., National Lock Washer Co.
McGinnis, P. B., Westinghouse Air Brake Co.
McGough, S. P., Lorain Steel Co.
MacIntire, S. H., Pressed Prism Plate Glass Co.
McKee, W. S., Vice-President, Edgar Allen American Manganese Steel Co.
MacLean, J. A., Boss Nut Co.
McMaster, C. L., Pratt & Lambert.
McMichael, J. G., President, Atlas Railway Supply Co., Manhattan Building.
Mann, Henry S., Representative, Goldschmidt-Thermit Co.
Marston, Glenn, Public Service Publishing Co.
Marvel, Frank W., The Buda Co.
Marys, Clifford P., Grip Nut Co.
Matheny, C. R., General Electric Co.
Maujer, A. R., Hill Publishing Co.
Merritt, W. G., The Chapman Valve Manufacturing Co.
Metterhausen, Carl, Secretary, Wallace Supply Co., 120 North Jefferson Street.
Midgley, Stanley W., The Curtain Supply Co.
Mills, Edwin S., Carnegie Steel Co.
Mills, Geo. F., Niles Bement Pond Co.
Milton, T., Electric Storage Battery Co.
Mitchell, H. M., Lyon Metallic Manufacturing Co.
Moffett, J. McC., Manager, The Chapman Valve Manufacturing Co.

CHICAGO — *Continued:*

Monroe, H. L., Manager, Railway Department, General Electric Co.
Mulligan, U. J., American Brake Shoe & Foundry Co.
Munoz, S. C., Duplex Metals Co.
Murphy, John Z., Chief Engineer, Chicago Railways Co.
Myers, H. B., Office Manager, Edgar Allen American Manganese Steel Co.
Naylor, N. C., Railway Steel Spring Co.
Newman Clock Co.
Newton, H. E., New Tone System Co.
Nicholas, Frederic, Associate Editor, Electric Railway Journal, 1570 Old Colony Building.
Nicholson, J. J., Murphy Varnish Co., 42–52 West 22d Street.
Noble, R. P., Westinghouse Air Brake Co.
Noyes, E. H., Aluminum Company of America.
Nuckels, C. C., Consolidated Car Heating Co.
Olberding, A. G., American Brake Shoe & Foundry Co.
Olmstead, C. J., Westinghouse Air Brake & Traction Brake Co.
Olsen, O. M., Spencer Otis Co.
Payne, Paul T., Dearborn Drug & Chemical Co.
Pease, L. M., National Brake & Electric Co.
Pettis, C. D., American Brake Shoe & Foundry Co., 1414 McCormick Building.
Piersen, Wm. J., The Adams & Westlake Co.
Pinckard, W. R., Westinghouse Electric & Manufacturing Co.
Pine, W. J., Railway Utility Co.
Place, C. W., General Electric Co.
Poole, S. K., Poole Bros.
Porter, J. W., First Vice-President, Electric Service Supplies Co., 303 Dearborn Street.
Redersen, A. W., Assistant Superintendent, Repair Shops, Chicago Railways Co.
Reel, George K., Pennsylvania Steel Co. and Maryland Steel Co.
Regester, C. W., Westinghouse Electric & Manufacturing Co., New York Life Building.
Rehm, N. F., Buyers' Index Co.
Reynolds, Jno. N., Simmons-Boardman Publishing Co.
Rhoades, C. W., Valentine & Co.
Rice, Ralph H., Division Engineer, Board of Supervising Engineers, Chicago Traction, 105 South La Salle Street.
Robinson, T. J., Ferguson Lange Foundry Co.
Rockwell, C. H., The O. M. Edwards Co.
Ross, James T., The Adams & Westlake Co.

CHICAGO — *Continued:*

Ross, John J., U. S. Metal & Manufacturing Co.
Rowntree, Harold, Secretary-Treasurer, Burdett-Rowntree Manufacturing Co., 515 Laflin Street.
Royal, C. B., Galena Signal Oil Co.
Rummel, A. D., Duplex Metals Co.
Ryder, B. H., American Steel & Wire Co.
Salsbury, E. V., W. T. Van Dorn Co.
Schauffler, C. E., Representative, Galena Signal Oil Co., 319 Railway Exchange.
Schumacher, Charles H., Chicago Pneumatic Tool Co.
Scott, H. N., Griffin Wheel Co.
Semple, C. B., Duplex Metals Co.
Shanahan, L. P., American Steel & Wire Co.
Sherman, L. B., Simmons-Boardman Publishing Co.
Simpson, J. G., Public Service Publishing Co.
Simpson, W. M., President, Railway Materials Co., Railway Exchange Building.
Sines, Harold S., Minerallac Electric Co.
Sisson, A. H., General Manager, Forsyth Bros. Co., 31 East Indiana Street.
Slingluff, W. H., John A. Roebling's Sons Co.
Smejkal, Jos., Jr., Engineer, Board of Supervising Engineers, Chicago Traction.
Smith, Alex., Buyers' Index Co.
Smith, Delbert C., The Buda Co.
Spohr, Frank S., Green Engineering Co.
Smith, G. J., Galena Signal Oil Co., 6033 Jefferson Avenue.
Steiger, J. H., American Brake Shoe & Foundry Co.
Stewart, B. S., Standard Underground Cable Co.
Swift, C. O., Crerar Adams Co.
Tate, H. F., National Conduit & Cable Co.
Tawse, J. G., American Brake Shoe & Foundry Co.
Taylor, E. S., Forsyth Brothers Co.
Thompson, J. S., Chief Engineer, American Brake Shoe & Foundry Co.
Thorn, W., Division Engineer, Board of Supervising Engineers, Chicago Traction, 105 South La Salle Street.
Townsend, E. R., Engineer, 125 Monroe Street.
Townsend, H. L., Electric Traction.
Tratman, E. E. R., Editor, Engineering News, 1144 Monadnock Block
Turner, Henry G., The Adams & Westlake Co.
Turner, O. E., General Electric Co.
Van Buskirk, James, Minerallac Electric Co.
Van Dorn, H. E., W. T. Van Dorn Co.

CHICAGO — *Continued:*

Van Dorn, Wm. E., The Van Dorn Co.
Van Dorn, W. T., The W. T. Van Dorn Co.
Van Patten, H. B., Murphy Varnish Co.
Van Schaick, A. P., Lackawanna Steel Co.
Volkins, Wm. J., Treasurer, The International Register Co.
Wade, Scott, Heywood Brothers & Wakefield Co.
Walbank, R. T., Railway Department, Glidden Varnish Co., 241 Railway Exchange Building.
Wallace, Chas. J., The Pantasote Co.
Walinger, Chas., Walinger Co.
Walsh, W. J., Resident Manager, Galena Signal Oil Co., 319 Railway Exchange Building.
Weaver, H. P., People's Gas Building.
Wells, Lloyd R., The Midvale Steel Co.
Wendt, P. W., Forged Steel Wheel Co.
Weston, Geo., Member and Engineer for Board of Supervising Engineers, Chicago Traction, 105 South La Salle Street.
Whipple, A. L., Ward Equipment Co., 1915 People's Gas Building.
White, F. P., Galena Signal Oil Co.
Wiley, J. R., Standard Underground Cable Co., 322 Rookery Building.
Wilhelm, E., Boss Nut Co.
Williams, C. P., National Lock Washer Co.
Wilt, B. C., McCord Manufacturing Co.
Winger, Stanley D., Green Engineering Co.
Witherby, Edwin E., General Vehicle Co.
Woltman, Ernst, A. & J. M. Anderson Manufacturing Co.
Woodward, A. H., President, International Register Co.

DECATUR:

Woodruff, E. C., Professor Electrical Engineering, James Milliken University.
Wright, C. P., American Brake Shoe & Foundry Co.
Wright, D. B., Lehon Company.
Wright, E. E., McKeen Motor Car Co.
Wright, W. V. D., Railway Steel Spring Co.
Wundrack, O., Ferguson Lange Foundry Co.
Young, C. D., Goldschmidt Thermit Co.

EAST ST. LOUIS:

Merker, H. F., Engineer Maintenance of Way, East St. Louis & Suburban Railway Co., 3rd & Broadway.
Parks, H. J., Electrical Engineer, East St. Louis & Suburban Railway Co., 20th & State Streets.
Tuncil, P. S., Electrical Engineer, East St. Louis & Suburban Railway Co.

HIGHWOOD:

Pease, L. A., Assistant Electrical Engineer, Chicago & Milwaukee Electric Railroad Co.

MATTOON:

Cox, Charles H., General Manager, Central Illinois Public Service Railway Co.

PEORIA:

Nicholson, J. A., General Electric Co.

ROCKFORD:

Jacques, L. W., Master Mechanic, Rockford & Interurban Railway Co.

SPRINGFIELD:

Leisenring, John, Signal Engineer, Illinois Traction Co.

INDIANA

ANDERSON:

Hemming, R. N., Superintendent of Motive Power, Union Traction Company of Indiana.

Kelsay, G. H., Superintendent of Power, Union Traction Company of Indiana.

ELKHART:

Griffin, L. A., Cable Conveyer Co.

FT. WAYNE:

Ritchie, R. R., Fort Wayne & Northern Indiana Traction Co.

Stevens, F. J., Master Mechanic, Fort Wayne & Northern Indiana Traction Co.

INDIANAPOLIS:

Bloss, W. H., District Sales Agent, Ohio Brass Co., 4811 Central Avenue.

Brown, Frank Erickson, Northey-Plummer, Ltd.

Chatfield, C. E., Northey-Plummer, Ltd.

Clark, L. M., Master Mechanic, Indianapolis Traction & Terminal Co.

Drake, L. J. Jr., Representative, Galena Signal Oil Co., 411 Traction Building.

Drew, James A., Indianapolis Brass Co.

Lee, W. H., Representative, Galena Signal Oil Co., 411 Traction Building.

Marsh, H. B., 931 Lemcke Building.

May, J. P., Northey-Plummer, Ltd.

Simmen, P. J., Northey-Plummer, Ltd.

West, W. C., Mechanical Expert, Galena Signal Oil Co., 410 Traction Building.

LAFAYETTE:

Bell, Geo., The Esterline Co.

Harding, C. F., Professor Electrical Engineering, Purdue University.

Smith, O. P., The Esterline Co.

MICHIGAN CITY:

Forsyth, B. H., The Ford & Johnson Co.

IOWA

BOONE:

Silverman, M., Electrical Engineer, Fort Dodge, Des Moines & Southern Railroad Co.

Munson, Charles, Master Mechanic, Cedar Rapids & Iowa City Railway & Light Co.

DES MOINES:

Lloyd, M. M., Master Mechanic, Interurban Railway Co.

KANSAS

LAWRENCE:

Shaad, Geo. C., Professor Electrical Engineering, University of Kansas.

PITTSBURGH:

Miers, M., Master Mechanic, Joplin & Pittsburgh Railway Co.

KENTUCKY

HENDERSON:

Lyne, George L., Passenger Agent & Superintendent, Henderson Traction Co.

LEXINGTON:

Stuck, W. G., Lexington Railway Co.

LOUISVILLE:

Augustus, J. D., Chatham Electric Switching Device Co.

Humphrey, Churchill, Humphrey & Humphrey, Realty Building.

Olmstead, E. S., Chatham Electric Switching Device Co.

NEWPORT:

Wampler, Frank, Master Mechanic, South Covington & Cincinnati Street Railway Co.

LOUISIANA

NEW ORLEANS:

Crump, R. L., with Ford, Bacon & Davis, 921 Canal Street.

Datz, L. C., Engineer Maintenance of Way, New Orleans Railway & Light Co., 323 Baronne Street.

NEW ORLEANS — *Continued:*

Davis, Geo. H., Ford, Bacon & Davis, 921 Canal Street.
Hardy, C. J., Resident Engineer, Ford, Bacon & Davis, 921 Canal Street.
McKinney, E. B., New Orleans Railway & Light Co., 323 Octavia Street.
von Phul, W., Ford, Bacon & Davis, 509 Walnut Street.

MARYLAND

ANNAPOLIS:

Crouse, David E., Engineer, Maryland Electric Railways Co.

BALTIMORE:

Batchelder, F. B., Mechanical Assistant, United Railways & Electric Co.
Clark, A. T., Superintendent of Rolling Stock & Shops, United Railways & Electric Company of Baltimore, 2951 Clifton Avenue.
Cole, H. A., Westinghouse Electric & Manufacturing Co.
Davis, J. H., Electrical Engineer, Baltimore & Ohio Railroad.
Harrall, J. E., Superintendent Distribution, United Railways & Electric Company of Baltimore.
Hill, John T., Vice-President, R. C. Hoffman & Co., Inc., Pennsylvania Steel Co., Maryland Steel Co.
Hood, J. M. Jr., Consulting Engineer, United Railways & Electric Company of Baltimore.
Leonhauser, H. A., Assistant Superintendent of Shops, United Railways & Electric Company of Baltimore.
Polk, Anderson, 608 Continental Building.
Staub, W. H., Purchasing Agent, United Railways & Electric Company of Baltimore.
Swift, W. H., Westinghouse Electric & Manufacturing Co.
Thomas, Carroll, Electrical Engineer, United Railways & Electric Company of Baltimore.
Weston, A. H., Mechanical Engineer, The T. H. Symington Co., Calvert Building.
Walden, A. E., Superintendent & Chief Engineer, Baltimore County Water & Electric Co.
Wolff, Augustus, Superintendent Motive Power, United Railways & Electric Company of Baltimore.
Woolford, W. A., Salesman, General Electric Co., 1600 Continental Building.

FREDERICK:

Coblentz, Oscar B., The Morris Iron Co.

MASSACHUSETTS

BOSTON:

Alexander, T. P., Westinghouse Electric & Manufacturing Co.
Anderson, Alfred E., Treasurer, A. & J. M. Anderson Manufacturing Co., 289 A Street.
Andrew, J. D., Superintendent Power Station, Boston Elevated Railway Co.
Ayer, J. M., Engineering Inspection, Boston Elevated Railway Co., 101 Milk Street.
Bancroft, C. F., Superintendent Motive Power, Bay State Street Railway Co.
Barby, F. A., Railroad Supplies, 230 South Terminal Station.
Barr, James C., The Rail Joint Co.
Burke, Pierce A., Safety Insulated Wire & Cable Co., 18 P. O. Square.
Bushnell, Fred N., Engineer, Stone & Webster Management Association.
Chapman, O. E., C. N. Wood Co.
Chapman, W. M., C. N. Wood Co.
Claflin, G. E., Director, Winona Railway & Light Co., 47 Ames Building.
Clark, Chas. S., Agent, Pennsylvania Steel Co.
Coakley, M. J., Samson Cordage Works.
Corning, John W., Electrical Engineer, Boston Elevated Railway Co., 439 Albany Street.
Dey, C. H. Jr., Assistant Engineer on Cable Testing, Boston Elevated Railway Co., 101 Milk Street.
Duclos, Arthur E., Massachusetts Chemical Co.
Duclos, L. O., Massachusetts Chemical Co.
Ewing, G. C., Westinghouse Electric & Manufacturing Co., 201 Devonshire Street.
Farnsworth, W. A., Standard Leather Packing Co.
Frothingham, F. E., Perry, Coffin & Burr, 60 State Street.
Furbush, E. W., Massachusetts Chemical Co.
Garrett, F. W., Superintendent, Albany Shops, Boston Elevated Railway Co., 443 Albany Street.
Gillespie, H. W., New York Sales Agent, Pennsylvania Steel Co., Maryland Steel Co.
Hale, A. A., Griffin Wheel Co.
Hall, F. D., Electrical Engineer, Boston & Maine Railroad Co.
Hawley, Cornell S., President, Laconia Car Co, 60 Congress Street.
Holst, E. W., Superintendent of Equipment, Bay State Street Railway Co., 84 State Street.
Jackson, D. C., Professor of Electrical Engineering, Massachusetts Institute of Technology.

BOSTON — *Continued:*

Jones, Chas. W., P. O. Box 2114.
Jourdan, F. M., Salesman, General Electric Co., 84 State Street.
Lake, Edw. N., 147 Milk Street.
Lane, J. J., Editor, *Street Railway Bulletin*, 12 Pearl Street.
Langford, F. W., Universal Safety Tread Co.
Law, George R., Mechanical Inspector, American Brake Shoe & Foundry Co.
Libby, H. L., Superintendent of Car Shops, Boston Elevated Railway Co., 2565 Washington Street.
Lindall, J., Superintendent of Rolling Stock & Shops, Boston Elevated Railway Co., 439 Albany Street.
Arthur D. Little,, Inc., 93 Broad Street.
Low, F. F., Architect, Boston Elevated Railway Co.
Luther, Henry R., President, Barbour-Stockwell Co.
Marsh, A. P., Inspector, Department of Wires and Conduits, Boston Elevated Railway Co., 552 Harrison Avenue.
Masters, W. T., Superintendent of Power Distribution, Boston Elevated Railway Co.
Montgomery, G. S., Universal Safety Tread Co.
Morris, L. P., Westinghouse Electric & Manufacturing Co.
Mosman, C. T., Engineer, Boston Office, General Electric Co., 84 State Street.
Parker, Lee H., Railway Engineer, Stone & Webster Engineering Corporation, 147 Milk Street.
Parmenter, Geo. A., Parmenter Fender & Wheel Guard Co.
Pasho, H. A., Superintendent of Elevated Division, Boston Elevated Railway Co.
Pierce, Charles C., Manager Railway Department, Boston Office, General Electric Co.
Record, C. A., Representative, Galena Signal Oil Co., 369 Atlantic Avenue.
Speare, L. R., Special Agent, Galena Signal Oil Co., 369 Atlantic Avenue.
Sprague, C. E., Agent, Railway Department, General Electric Co., 84 State Street.
Steward, H. M., Chief Engineer Maintenance of Way, Boston Elevated Railway Co.
Stimson, David, Frank Ridlon Co.
Stone, F. J., The Electric Storage Battery Co., 60 State Street.
Stone & Webster Engineering Corporation, 147 Milk Street.
Whiting, S. Edgar, Assistant to Superintendent Rolling Stock and Shops, Boston Elevated Railway Co.
Wilhelm, P. H., Standard Leather Packing Co.
Winsor, P., Chief Engineer Motor Power & Rolling Stock, Boston Elevated Railway Co., 101 Milk Street.
Wood, C. N., C. N. Wood Co.

BRIGHTWOOD:

Pearson, Henry, President, Wason Manufacturing Co.

CAMBRIDGE:

Baker, C. F., 59 Magazine Street.

Field, William W., Salesman, Barbour-Stockwell Co., 205 Broadway.

Mason, H. C., Representative, Galena Signal Oil Co., 432 Broadway.

Stockwell, Fred F., Treasurer, Barbour-Stockwell Co.

CANTON:

Winn, Fred H., Master Mechanic, Blue Hill Street Railway Co.

HAVERHILL:

Mellon, W. S., Superintendent Lines and Bonding, Massachusetts Northeastern Electric Railway Co., 50 Merrimac Street.

MEDFORD:

Doty, Clark, 25 King Avenue.

NEEDHAM:

Murdoch, David, P. O. Box 348.

Pellissier, G. E., Pellissier Engineering Co., 796 Summit Avenue.

SPRINGFIELD:

Hatmaker, C. F., Gilbert & Barker Manufacturing Co.

Johnson, C. F., Wason Manufacturing Co.

Pease, A. H., Secretary, Wason Manufacturing Co.

SAGAMORE:

Keith, E. S. S., President, Keith Car & Manufacturing Co.

WATERTOWN:

Fairbanks, A. C., President, Waterproof Paint Co.

WEST NEWTON:

Gammons, R. F., 2nd, Treasurer, United States Electric Signal Co.

WEST SOMERVILLE:

Fletcher, A. O., Galena Signal Oil Co., 61 Lowden Avenue.

WORCESTER:

Boyden, C. G., Worcester Polytechnic Institute.

Bradley, J. E., Proprietor, Osgood, Bradley & Son, 18 Grafton Street.

Hoeftmann, A. O. O. Electrical Engineer, American Steel & Wire Co.

Richey, A. S., Professor of Electrical Engineering, Worcester Polytechnic Institute.

Sturdevant, Chas. R., Electrical Engineer, American Steel & Wire Co., 94 Grove Street.

Turner, C. H., P. O. Box 645.

MICHIGAN

DETROIT:

Clark, W. W., Kerwin Machine Co.
Eayrs, T. C., Westinghouse Electric & Manufacturing Co.
Edwards, Allen F., Purchasing Agent, Detroit United Railway.
Griffin, J. M., President, Wheel Truing Brake Shoe Co.
Hinmon, W. E., Peter Smith Heater Co.
Kerwin, James J., Kerwin Machine Co.
Livsey, J. H., Manager, General Electric Co., 1410 Majestic Building.
McKee, W. M., Peter Smith Heater Co.
Paye, W. E., Berry Brothers, Ltd.
Phelan, M. J., Peter Smith Heater Co.
Pierson, F. B., Manager, National Lead Co.
Rifenberick, R. B., Consulting Engineer, Detroit United Railway Co., The Ford Building.
Smith, C. H., Berry Brothers, Ltd.
Smith, D. W., President, Peter Smith Heater Co.
Smith, Elmer J., Peter Smith Heater Co.
Williams, H. S., Peter Smith Heater Co., 47 Brady Street.

FLINT:

Gundry, James E., Reliable Trolley Retriever.

GRAND RAPIDS:

Livingston, W. E., Store Keeper, Grand Rapids Railway Co., 38 North Ionia Street.
Weber, T. J., Consulting Engineer, Child, Hulswitt & Co.

KALAMAZOO:

Cook, E., Root Spring Scraper Co.
Johnson, O. P., Star Brass Works.
Reynolds, W., Root Spring Scraper Co.
Root, F. N., Root Spring Scraper Co.
Root, Newton, Root Spring Scraper Co.

MINNESOTA

MINNEAPOLIS:

McDonald, W. D., Branch Manager, Westinghouse Electric & Manufacturing Co.

WINONA:

Howard, R. M., General Manager, Winona Railway & Light Co.

MISSISSIPPI

GREENVILLE:

Lenz, E. J., Superintendent & Electric Engineer, Delta Electric Light Power & Manufacturing Co.

MISSOURI

KANSAS CITY:

Brown, E. C., Ohio Brass Co.
McMaster, R. K., Engineering Department, Kansas City Electric Light Co., 1500 Grand Avenue.
Palmer, I. H., Galena Signal Oil Co.
Smith, G. J., Master Mechanic, Metropolitan Street Railway Co., 10th & Lister Avenues.
Swenson, S. O., Electrical Engineer, Kansas City Terminal Railway Co., 23rd & Grand Avenue.
Tritle, J. S., Westinghouse Electric & Manufacturing Co.

ST. LOUIS:

Adreon, E. L., Vice-President & General Manager, American Brake Co., 1932 North Broadway.
Alt, Walter, St. Louis Car Co.
Beggs, John I., St. Louis Car Co.
Blewett, Scott, H., General Agent, American Car & Foundry Co.
Cass, C. P., Westinghouse Air Brake Co.
Cheatham, Paul G., Standard Steel Works Co.
Cohn, G. H., Electric Traction Supply Co.
Crawford, S. W., Manager Railroad Department, More Jones Brass & Metal Co., 3144 North Broadway.
Davis, C. L. L., Scullin Gallagher Iron & Steel Co., 1401 Syndicate Trust Building.
Emery, E. A., The Emery Pneumatic Lubricator Co.
Evins, A. Y., More Jones Brass & Metal Co.
Gerhard, Harry H. Manager, C. A. Wood Preserver Co.
Kaiser, D. L., Westinghouse Electric & Manufacturing Co.
Kippenberger, Geo. L., St. Louis Car Co.
Lawler, T. J., Salesman, American Roll Gold Leaf Co., 4296 Page Avenue.
Koch, Gus, St. Louis Car Co.
Le Grand, Nic., St. Louis Car Co.
McAloney, N. J., Emery Pneumatic Lubricator Co.
Meissner, Edw. B., St. Louis Car Co.
Mendenhall, J. B., Special Representative, National Lead So., Liggett Building.
Mills, S. H., Westinghouse Traction Brake Co.
Norris, W. K., McQuay-Norris Manufacturing Co.
O'Malley, Owen, Electric Traction Supply Co.
Partridge, A. S., 415 Pine Street.
Paton, James, The St. Louis Surfacer & Paint Co.
Pero, H. G., Chicago Manager, McQuay-Norris Manufacturing Co.

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Travis, C. R., McQuay-Norris Manufacturing Co.

Uthoff, O. W., Electric Traction Supply Co.

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NEBRASKA

OMAHA:

Anderson, C. O., Anderson Brake Adjuster Co.

Austin, W. A., Anderson Brake Adjuster Co.

Meyer, Martin, Meyer Safety Guard Co.

NEW JERSEY

ATLANTIC CITY:

Koury, C. M., C. M. Koury Co.

BOUND BROOK:

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BURLINGTON:

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EAST RUTHERFORD:

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HADDONFIELD:

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KEYPORT:

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LYNDHURST:

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MILLVILLE:

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PLAINFIELD:

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SILVER LAKE:

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TRENTON:

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WEST NEW YORK:

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WESTVILLE:

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Doherty, John F., Foreman, Brooklyn Rapid Transit System, 259 39th Street.

Drolet, E., Foreman Printer, Brooklyn Rapid Transit System, 342 54th Street.

Duff, Howard, Testing Bureau, Brooklyn Rapid Transit System, 359 Lewis Avenue.

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Erhardt, John, General Foreman, Brooklyn Rapid Transit System, 215 Hendrix Street.

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BROOKLYN — *Continued:*

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Gove, W. G., Superintendent of Equipment, Brooklyn Rapid Transit System.

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FLUSHING:

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Edson, Frank, Hale & Kilburn Co.

Elliott, Clinton, Treasurer, Eastern Advertising Co., 576 5th Avenue.

Ellicott, C. R., Westinghouse Traction Brake Co., 165 Broadway.

Ellicott, J. R., Eastern Manager, Westinghouse Air Brake Co., 165 Broadway.

Elmquist, F. A., Railway Representative, The Sherwin-Williams Co., 50 Church Street.

NEW YORK — *Continued:*

Emerson, Harrington, President, The Emerson Co., 30 Church Street.

Emery, James A., Engineer, Ford, Bacon & Davis, 115 Broadway.

Evans, H. C., Sales Agent, The Lorain Steel Co., 30 Church Street.

Farmer, Thomas, Jr., District Manager, Consolidated Car Heating Co., 149 Broadway.

Fire Underwriters' Electrical Bureau, 68 William Street.

Fiske, H. A., H. W. Browne & Co., 73 Maiden Lane.

Fleming, Wm. J., Jr., Salesman, Automatic Ventilator Co., 120 Liberty Street.

Flodin, B. A., Automatic Register Co.

Flower, D. B., J. N. Johns Manufacturing Co.

Floy, Henry, Consulting Engineer, 165 Broadway.

Ford, Geo. H., General Manager, Automatic Ventilator Co., 120 Liberty Street.

Foulks, J. A., Indianapolis Switch & Frog Co.

Fowler, Geo. L., Consulting Engineer, 83 Fulton Street.

Fox, Geo. E., Curtain Supply Co.

Garland, N. M., District Sales Manager, Ohio Brass Co., 30 Church Street.

Gibbs, Geo., Engineer, Electric Traction and Station Construction, Pennsylvania Tunnel & Terminal Railroad Co., 7th Avenue and 32d Street.

Gillon, G. L., Vice-President and Treasurer, Watson-Stillman Co., 50 Church Street.

Goertner, F. J., Sales Manager, Semon Bache & Co., West & Hubert Streets.

Goldschmidt, E. L., Traveling Representative, Waclark Wire Co., 20 Exchange Place.

Goode, Henry A., Wonham, Sanger & Bates, 30 Church Street.

Gordon, R. L., Assistant to President, Standard Motor Truck Co., 170 Broadway.

Gorsuch, W. S., Jr., Assistant Electrical Engineer, New York Railways Co., 775 7th Avenue.

Gregory, E. A., American Brake Shoe & Foundry Co.

Green, F. V., Westinghouse Traction Brake Co., 165 Broadway.

Gresham, W. B., Lorain Steel Co.

Griffin, H. W., The Union Switch & Signal Co.

Hall, C. W., Railway Improvement Co., 165 Broadway.

Hall, W. A., The Yale & Towne Manufacturing Co.

Hall, Walter A., Assistant Engineer, Railway Improvement Co., 165 Broadway.

NEW YORK — *Continued:*

Hartmann, E. F., President, Carbolineum Wood Pressing Co., 182 Franklin Street.

Harvie, W. J., care of J. G. White & Co., 43 Exchange Place.

Hartwell, H., Assistant to Vice-President, The Pearson Engineer Corp., Ltd., 115 Broadway.

Hawks, H. D., care of United Metals Signals Co., 42 Broadway.

Hayes, M. D., The Midvale Steel Co.

Hayes, R. F., Eastern Manager, Curtain Supply Co., 50 Church Street.

Hayward, H. S., Jr., 30 Church Street.

Hedley, E. M., Special Expert, Galena-Signal Oil Co., Room 1006, 26 Broadway.

Hegeman, B. A., Jr., President, United States Metal & Manufacturing Co., 165 Broadway.

Hegeman, Harold A., Salesman, United States Metal & Manufacturing Co., 165 Broadway.

Henshaw, F. V., Consulting Engineer, Bankers Trust Building, 14 Wall Street.

Herrick, A. B., 64 Wall Street.

High, J. M., Manager of Sales Department, Pantasote Co., 11 Broadway.

Hill, E. R., Assistant to Chief Engineer Electric Traction, Pennsylvania Tunnel & Terminal Railroad Co., Pennsylvania Station.

Hillman, E. D., Mechanical Engineer, U. S. Metal & Manufacturing Co., 165 Broadway.

Horne, L. W., Draftsman, Interborough Rapid Transit Co., care of Mr. J. S. Doyle, 98th Street and 3d Avenue.

Hovey, W. G., The Okonite Co.

Hulbert, W. R., Goldschmidt-Thermit Co., 90 West Street.

Inwood, Harry A., The Standard Paint Co.

Jackson, Walter, Associate Editor, Electric Railway Journal, 239 West 39th Street.

Janes, E. L., Salesman, American Brake Shoe & Foundry Co., 30 Church Street.

Jay, J. C., Jr., Agent, The Pennsylvania Steel Co., 71 Broadway.

Jeandron, W. J., 172 Fulton Street.

Jennings, Peter S., President, Hildreth Varnish Co., 90 West Street.

Johnson, C. L., Buhne Metal Packing Co., 93 Nassau Street.

Jordan, W. T., The Under-Feed Stoker Company of America, 11 Broadway.

Junkins, Sydney E., Vice-President, Westinghouse, Church, Kerr & Co., 10 Bridge Street.

NEW YORK — *Continued:*

Katté, E. B., Chief Engineer of Electric Traction, New York Central & Hudson River Railroad Co., Grand Central Station.
Kayler, W. G., Westinghouse Traction Brake Co.
Kearney, James R., Western Electric Co.
Keiser, C. B., Manhattan Division, Pennsylvania Railroad Co.
Kelly, Wm. F., care of Ford, Bacon & Davis, 115 Broadway.
Kent, Henry R., Vice-President, Westinghouse, Church, Kerr & Co., 10 Bridge Street.
Kerschner, W. R., 50 Church Street.
Ketcham, F. O., General Manager of Railroad Department, E. L. Post Co., 50 Cliff Street.
Keyes, C. B., Engineer, The General Electric Co., 30 Church Street.
Keyes, W. F., Secretary and Treasurer, F. E. Keyes & Son, Ltd., 20 Broad Street.
Keyes, S. B., 350 W. 18th Street.
Killion, F. D., Western Electric Co.
Kingsley, F., Electric Railway Journal.
Kitchen, F. T., Gold Car Heating & Lighting Co.
Kucera, J. A., Business Manager, Electric Railway Journal, 239 W. 39th Street.
Lake, W. A., The Pantasote Co., 11 Broadway.
Lang, Felix, Goldschmidt-Thermit Co., 90 West Street.
Latey, H. N., care of Railway Department, General Electric Co., 30 Church Street.
Lawrence, F. W., Engineer, Electrical Securities Corporation, 62 Cedar Street.
Lee, W. B., Civil Engineer, 30 Church Street.
Leeds, E. L., Mechanical Engineer and Salesman, Niles-Bement-Pond Co., 111 Broadway.
Lillibridge, Ray D., Wagner Electric Co., 192 Broadway.
Litchfield, N., Engineer of Car Equipment, Interborough Rapid Transit Co., 98th Street and 3d Avenue.
Long, Robt., Westinghouse Air Brake Co., 165 Broadway
Loomis, Bruce E., Marsh & McLennan, 19 Cedar Street.
Lounsbury, Charles, American Railway Supply Co.
Low, F. R., Editor, *Power,* 505 Pear Street.
Lumsden, T. H., Street Railways Advertising Co., Fuller Building.
McAlarney, J. A., Carnegie Steel Co.
McBee, A. E., Vice-President, Street Railways Advertising Co., Fuller Building.
McCabe, H. P., J. J. McCabe.
McClellan, William, Vice-President, The Campion-McClellan Co., 90 West Street.

NEW YORK — *Continued:*

McClelland, R. J., Electrical Bond & Share Co., 71 Broadway.
McConnaughy, H. G., Dearborn Drug & Chemical Works, 299 Broadway.
MacDuffie, R. L., Vice-President, Wendell & MacDuffie Co.
McGee, J. G., Hildreth Varnish Co.
MacGovern, Frank, MacGovern Co.
McGowan, W. S., Manager, American Brake Shoe & Foundry Co., 30 Church Street.
McGraw, Harold W., Electric Railway Journal.
McIver, Alexander, Commercial Engineer, Westinghouse Electrical & Manufacturing Co., 165 Broadway.
McKinney, E. B., Railway Improvement Co.
McWhirter, J. S., Superintendent of Equipment, Third Avenue Railroad Co., 65th Street and 3d Avenue.
Mace, Romaine, Salesman, The Okonite Co., Ltd., 253 Broadway.
Mailloux, C. O., 90 West Street.
Manson, A. J., Consulting Engineer, Westinghouse Electric & Manufacturing Co., 165 Broadway.
Manson, G. T., General Superintendent, The Okonite Co., Ltd., 53 Broadway.
Marsh, C. J., Manager, Standard Underground Cable Co.
Marshall, R. W., General Manager, Traction Materials Co.
Martin, L. G., Engineer, The Okonite Co., Ltd., 253 Broadway.
Martin, T. C., Executive Secretary, National Electric Light Association, 29 W. 39th Street.
Mason, E. R., Electric Service Supplies Co.
Matthews, T. A., President, New York & New Jersey Land Co., 165 Broadway.
Maycock, Jos., Pratt & Lambert, 185 Madison Avenue.
Mayne, J. G., Galena Signal Oil Co.
Meeteer, Wesley, President, Wallace Supply Co., 26 Cortlandt Street.
Megeath, S. A., Vice-President and General Manager, Galena Signal Oil Co., 26 Broadway.
Methfessel, C. A., The Duff Manufacturing Co.
Mizuno, S., Engineer, Mitsui & Co., Ltd., 445 Broome Street.
Moritz, Edw. P., New York Manager, Edgemoor Iron Co., 111 Broadway.
Mullaney, T. F., Chief Engineer, Third Avenue Railroad Co., 130th Street and 3d Avenue.
Munford, I. H., Valentine & Co.
Murphy, P. J., Ford, Bacon & Davis, 115 Broadway.
Nelson, J. C., Engineer, Ford, Bacon & Davis, 115 Broadway.
Noll, John, Continuous Rail Co.

NEW YORK — *Continued:*

Oberlander, M. A., Western Electric Co.
O'Brian, T. P., The O. M. Edwards Co.
Oelerich, J. F., Transportation Utilities Co.
Oesterreich, H. E., Wendell & MacDuffie Co., 165 Broadway.
Old, A. F., Manager, The Hale & Kilburn Manufacturing Co., 39 Union Square.
Osborn, Frederick H., American Automatic Switch Co.
Pearson, W. A., Rio de Janeiro Traction Light & Power Co., 135 Front Street.
Pegram, G. H., Chief Engineer, Interborough Rapid Transit Co., 165 Broadway.
Perkins, Alfred P., Western Electric Co.
Perry, James W., General Manager Electrical Department, The H. W. Johns-Manville Co., 100 William Street.
Pilcher, A. H., American Surety Co.
Pizzini, A. J., International Time Recording Co., 165 Broadway.
Plogsted, W. J., Resident Engineer, General Railway Signal Co., 55 Liberty Street.
Porter, G. G., Chicago Varnish Co., 50 Church Street.
Post, George A., President, Standard Coupler Co.
Post, Geo. A., Jr., Sales Manager, Standard Coupler Co.
Potter, R. R., Superintendent Equipment, New York, Westchester & Boston Railway Co., Unionport Road, Bronx.
Pratt, C. E., Automatic Register Co.
Pratt, F. E., United States Metal & Manufacturing Co.
Price, Thomas, The Midvale Steel Co.
Quereau, C. H., Superintendent Electrical Equipment, New York Central & Hudson River Railroad Co., Grand Central Station.
Quinn, Walter J., Assistant Engineer, Third Avenue Railroad Co., 130th Street and 3d Avenue.
Randall, F. C., Manager, Allis-Chalmers Co., 71 Broadway
Rankin, Arthur W., The National Surety Co.
Raynor, Clinton W., The National Surety Co.
Rapp, J. P., Forged Steel Wheel Co., 170 Broadway.
Reed, L. N., Westinghouse Electric & Manufacturing Co., 165 Broadway.
Reed, W. Boardman, President, Otsego & Herkimer Railroad Co., 420 E. 25th Street.
Reeves, W. F., Assistant Engineer, Interborough Rapid Transit Co., 165 Broadway.
Remelius, C., 306 W. 51st Street.
Reynolds, O. H., Wm. Jessop & Sons Steel Co., 91 John Street.
Robbins, A. E., Gold Car Heating & Lighting Co.

NEW YORK — *Continued:*

Robertson, M. W., Le Valley-Vitae Carbon Brush Co.
Robinson, L., Standard Varnish Works.
Roth, F. W., Salesman, John Streeter Co., 30 Church Street.
Rowntree, Bernard, 50 Church Street, Room 1774.
Ryder, E. M. T., Engineer Maintenance of Way, Third Avenue Railroad Co., 3d Avenue and 130th Street.
Samuelson, F., Assistant Auditor, New York Railways Co., 621 Broadway.
Sanderson & Porter, Engineers, 52 William Street.
Sanger, Ralph, Wonham, Sanger & Bates, 30 Church Street.
Sauvage, W. H., Standard Coupler Co.
Sawyer, W. H., Ford, Bacon & Davis, 115 Broadway.
Schlegell, V. Von, Hale & Kilburn Co.
Scott, Charles F., General Electric Co., 30 Church Street.
Shepard, F. H., Westinghouse Electric & Manufacturing Co., 165 Broadway.
Simmons, E. A., Vice-President, *Railroad Age Gazette,* 83 Fulton Street.
Sinclair, J. J., Westinghouse Electric & Manufacturing Co., 165 Broadway.
Slimp, J. E., District Sales Agent, Ohio Brass Co., 30 Church Street.
Smiley, J. B., Assistant Sales Agent, Pennsylvania Steel Co., 71 Broadway.
Smith, C. E., Manager, Electrical Department, Standard Paint Co., 100 William Street.
Smith, E. B., Salesman, American Brake Shoe & Foundry Co., 30 Church Street.
Smith, H. E., Electric Traction.
Southwell, J. Ernest, Mechanical Expert, Galena Signal Oil Co.
Spear, G. W., Vice-President and Eastern Manager, Dearborn Drug & Chemical Works, 299 Broadway.
Stacey, J. A., The Lorain Steel Co.
Stanley, V. C., General Manager, Manhattan Fire Alarm Co., 19 Barclay Street.
Stanton, W. T., General Electric Co.
Starrett, M. G., 100 Broadway.
Stearns, E. H., New York Agent, The Adams & Westlake Co., 30 Church Street.
Stebbins, Theodore, Herrick & Stebbins, 14–16 Church Street.
Stieler, F. C., Westinghouse Electric & Manufacturing Co., 165 Broadway.
Steins, Halsey, W. J. Jeandron.
Stitzer, A. B., care of Ford, Bacon & Davis, 115 Broadway.

NEW YORK — *Continued:*

Stocks, C. W., American Electric Railway Association, 29 W. 39th Street.

Stott, H. G., Superintendent Motive Power, Interborough Rapid Transit Co., 600 W. 59th Street.

Swenson, Bernard V., Street Railways Advertising Co., Fuller Building.

Thomson, D., Atlas Supply Co., 38 Park Row.

Thurston, J. L., Hildreth Varnish Co., 90 West Street.

Townley, Calvert, Assistant to President, Westinghouse Electric & Manufacturing Co.

Trawick, S. W., Agent Railway Department, General Electric Co., 30 Church Street.

Trubee, W. A., Galena Signal Oil Co., 26 Broadway.

Twining, Wm. S., Ford, Bacon & Davis, 115 Broadway.

Vail, Carl M., Treasurer, Westinghouse, Church, Kerr & Co., 10 Bridge Street.

Valentine, L. B., Second Vice-President, Valentine & Co., 257 Broadway.

Van Angen, F., E. C. Long Co.

Van Houten, E. W., Assistant to President, American Brake Shoe & Foundry Co.

Varian, Arthur, Salesman, Eppinger & Russell Co., 165 Broadway.

Vehslage, E. C., Bonney Vehslage Tool Co.

Wade, W. O., Railway Improvement Co.

Walker, Edmund H., Vice-President, Standard Coupler Co.

Wallace, F. W., Waclark Wire Co.

Wallace, J. F., Electric Properties Co., 10 Bridge Street.

Wampler, William, Forsyth Bros. Co., 26 Cortland Street.

Warfield, F. P., Duell, Warfield & Duell, 2 Rector Street.

Warren Howard S., Engineer, American Telegraph & Telephone Co., 15 Dey Street.

Weaver, W. D., Editor, *Electrical World*, 239 W. 39th Street.

Weeks, W. H., Bryan Marsh Works, of General Electric Co.

Westinghouse, Church, Kerr & Co., Engineers, 10 Bridge Street.

Weston, F. W., Standard Steel Works Co., 50 Church Street.

White, J. G., & Co., 43 Exchange Place.

Whitney, T. B., Jr., Engineer of Design, Hudson & Manhattan Railroad Co., 30 Church Street.

Whyte, W. C., American Infusion Steel Process Co.

Wilder, Clifton W., Electrical Engineer, Public Service Commission, First District, 154 Nassau Street.

Wilson, D. H., Jr., President, Wilson Storage Battery Co., 50 Church Street.

NEW YORK — *Continued:*

Wilson, H. M., Vice-President, The McGraw Publishing Co., 239 W. 39th Street.
Wilson, J. MacNaul, Wilson Remover Co.
Wilson, James Whitney, Wilson Remover Co.
Wing, L. J., Director, L. J. Wing Manufacturing Co., 352 W. 13th Street.
Woodin, W. H., Assistant to President, American Car & Foundry Co., 165 Broadway.
Yardley, C. B., Jr., Railroad Representative, Jenkins Bros., 80 White Street.
Yereance, W. B., Consulting Engineer, 128 Broadway.
Young, C. G., Consulting Engineer, Bankers' Trust Building, Wall and Nassau Streets.

NIAGARA FALLS:

Slocum, C. V., Titanium Alloy Manufacturing Co.

OLEAN:

Page, Wilson K., Master Mechanic, Western New York & Pennsylvania Traction Co.

PORT RICHMOND:

Greb, Carl, Engineer, Port Richmond & Bergen Point Ferry Co.
Klein, H., Foreman, Port Richmond & Bergen Point Ferry Co.

RICHMOND HILL:

Gwydir, Daniel, Shop Foreman, Brooklyn Rapid Transit System, Williamsburg Road & Green Street.

ROCHESTER:

Cadle, C. L., Electrical Engineer, New York State Railways.
Cameron, G. M., Master Mechanic, New York State Railways, 3 Marigold Street.
Cole, R., Yawman & Erbe Manufacturing Co.
Falconer, D. P., Assistant Engineer, Maintenance of Way, New York State Railways, 267 State Street.
Gwaltney, R. H., T. H. Symington Co.
Howe, W. K., Chief Engineer, General Railway Signal Co.
Kamps, S. L., T. H. Symington Co.
Leake, R. C., General Railway Signal Co.
Maher, John E., Secretary, New York State Sewer Pipe Co.
Slemin, H. C., Sales Manager, Stromberg Carlson Telephone Manufacturing Co.
Sperry, Henry M., Sales Manager, General Railway Signal Co.

SCHENECTADY:

Armstrong, A. H., Salesman, General Electric Co.
Barry, C. E., Railway Department, General Electric Co.
Barry, J. G., Manager Railway Department, General Electric Co.

SCHENECTADY — *Continued:*

Carey, W. Gibson, General Electric Co.
Case, F. E., Engineer, Railway Equipment Department, General Electric Co.
Connely, C. B., Engineering Department, General Electric Co.
Dodd, S. T., General Electric Co.
Doyle, F. J., Master Mechanic, Schenectady Railway Co., Fuller Street Shops.
Eveleth, C. E., General Electric Co.
Gale, F. H., General Electric Co.
Hill, G. H., Assistant Engineer of Railway and Truck Department, General Electric Co.
Layng, J. F., General Electric Co.
Potter, W. B., Engineer of Railway and Truck Department, General Electric Co.
Priest, E. D., General Electric Co.
Regan, J. J., General Electric Co.
Schermerhorn, G. L., Railway Engineering Department, General Electric Co.
Shugg, L. W., General Electric Co.
Tinnerholm, Aug. F., Mica Insulator Co.
Waller, E. P., Railway Department, General Electric Co.
Wright, W. H., Proprietor, Schenectady Varnish Co.

SYRACUSE:

Aberdeen, H. Lizars, Railway Roller Bearing Co.
Archbold, W. K., President, Archbold-Brady Co.
Barnes, J. P., Assistant Electrical Engineer, Syracuse Rapid Transit Railway Co.
Brewster, W. D., Secretary, National Brake Co., 1103 Madison Street.
Brown, Geo. N., Assistant Engineer, Syracuse Rapid Transit Railway Co., 301 Slocum Avenue.
Buchanan, Frank, The Crouse Hinds Co.
Chaffee, Edward F., The O. M. Edwards Co.
Gidley, Daniel C., Crouse Hinds Co.
Hills, A. F., The Crouse Hinds Co.
Hinman, F. L., General Foreman, Oneida Railway Co., Gridley Building.
Honold, P. J., Purchasing Agent, Utica & Mohawk Valley Railway Co.
Roundey, E. P., Engineer, Maintenance of Way, Syracuse Rapid Transit Railway Co.
Tilton, B. E., General Manager, Syracuse Rapid Transit Railway Co.
Vandegrift, James B., Railway Roller Bearing Co.

TROY:

Chapman, W. A., The Rail Joint Co.

Taylor, John, President, Taylor Electric Truck Co.

Taylor, Walter E., Assistant Superintendent, Taylor Electric Truck Co.

UTICA:

Ayers, J. R., General Foreman, Utica & Mohawk Valley Railway Co., 9 Sunset Place.

French, M. J., Engineer Maintenance of Way, Utica & Mohawk Valley Railway Co.

WATERTOWN:

Whyte, F. M., New York Air Brake Co.

WHITE PLAINS:

Robertson, P. W., Assistant Engineer Car Equipment, Interborough Rapid Transit Co., 161 S. Broadway.

WOODHAVEN:

Barnes, H. H., Foreman, Brooklyn Rapid Transit System, Willard Avenue.

Stoeltzing, H. E., Assistant to Superintendent Power, Brooklyn Rapid Transit System, 119 Vandeveer Place.

YONKERS:

Smith, W. N., Consulting Engineer, 72 Livingston Avenue.

NORTH CAROLINA

ASHEVILLE:

Cooper, O. W., Superintendent Track., Asheville Electric Co.

CHARLOTTE:

Latta, E. D., Jr., Vice-President, Charlotte Consolidated Construction Co.

HIGH POINT:

Thomas, Perlay A., Southern Car Co.

SALISBURY:

Coler, W. N., 3d, W. N. Coler & Co., Engineering Department.

OHIO

AKRON:

Roberts, Wm., Master Mechanic, Northern Ohio Traction & Light Co.

CANTON:

Hollis, Joseph, The Trolley Supply Co.

McLain, J. E., President, The Trolley Supply Co.

CINCINNATI:

Brett, J. A., Manager, Westinghouse Electric & Manufacturing Co., 1104 Traction Building.

Brooks, LeRoy, Jr., Secretary, Tool Steel Gear & Pinion Co.

CINCINNATI — *Continued:*

Buck, H. S., Pollak Steel Co.
Clark, D. B., Cincinnati Car Co.
Dunning, Robert, General Manager, Cincinnati Car Co.
Ebert, H. C., President, The Cincinnati Car Co.
Gilliland, C. R., Westinghouse Electric & Manufacturing Co.
Holmes, W., Galena-Signal Oil Co.
Johnson, A. L., Electric Railway Equipment Co.
Jones, Frank, Cincinnati Car Co.
Kipp, John G., Sales Manager, Electric Railway Equipment Co.
MacAlister, W. H., Comptroller, The Cincinnati Car Co., 809 Traction Building.
Marsh, H. C., Salesman, General Electric Co.
Pollak, Bernard, The Pollak Steel Co.
Pollak, J. A., The Pollak Steel Co.
Porter, K. E., Carnegie Steel Co.
Sawtelle, C. E., Tool Steel Gear & Pinion Co.
Sawtelle, E. S., Tool Steel Gear & Pinion Co.
Tegler, L. A., Tool Steel Gear & Pinion Co.

CLEVELAND:

Alexander, J. H., Chief Engineer, City Street Railway Commission.
Andrews, R. L., Glidden Varnish Co.
Arnold, George, Cleveland Frog & Crossing Co.
Arthur, H. G., Niles Car & Manufacturing Co.
Asmus, W. G., Insurance Engineer, 712 Electric Building.
Beam, E. E., Cleveland Trolley Wheel Co.
Beaser, William, Jr., Treasurer, The Whitmore Manufacturing Co.
Bendelari, F. N., President, The Acme Indicator Co.
Billau, H. E., The Sherwin-Williams Co.
Brady, W. B., Assistant Superintendent, National Carbon Co.
Braggins, R. R., Manager Electrical Department, H. W. Johns-Manville Co., 813 Superior Avenue.
Clark, C. H., Engineer Maintenance of Way, The Cleveland Railway Co.
Cole, H. W., The Holland Trolley Supply Co.
Cotabish, N. C., Sales Manager, National Carbon Co.
Crecelius, L. P., Superintendent of Power, The Cleveland Railway Co.
Dail, W. A., National Lead Co.
Day, W. P., The International Steel Tie Co.
Emery, C. D., The Universal Lubricating Co.
Figsby, F. H, System Manager, Ernst & Ernst, 1200 Schofield Building.

CLEVELAND — *Continued:*

Forward, Ross, Eclipse Railway Supply Co.
French, H. W., American Bitumastic Enamel Co.
Hanna, J. A., Sales Manager, Niles Car & Manufacturing Co., 312 Electric Building.
Henderson, John P., Marflow Railway Appliance Co.
Hoge, James B., Automatic Signal & Appliance Co.
Howatt, Gerald, The Electric Railway Improvement Co.
Huber, Wm. E., The Electric Railway Improvement Co.
Hutchinson, R. P., Carnegie Steel Co.
Kathe, F. D., National Carbon Co.
Kling, L. A., Superintendent, G. C. Kuhlman Car Co.
Lawyer, W. H., The Whitmore Manufacturing Co.
Lintern, Wm., The Holland Trolley Supply Co.
Lippincott, H. S., American Bitumastic Enamel Co.
Lucas, G. C., General Manager, The Cleveland Frog & Crossing Co.
McAdams, S. L., Cleveland Trolley Wheel Co.
Martindale, E. H., National Carbon Co.
O'Connor, Wallace, National Carbon Co.
Parker, L. G., Assistant Manager of Sale, Cleveland Frog & Crossing Co., 6917 Bessemer Avenue.
Riley, W. T., American Bitumastic Enamel Co.
Rinker, L. J., The Electric Railway Improvement Co.
Robbins, F. C., President, Niles Car & Manufacturing Co.
Roberts, E. P., President, Cleveland Engineering Society.
Sawyer, L. P., The Buckeye Electric Co.
Schmidt, E. E., Electric Railway Improvement Co.
Schmidt, E. H., The National Malleable Castings Co.
Scofield, S. W., Universal Lubricating Co.
Scullin, Terance, Master Mechanic, The Cleveland Railway Co.
Small, T. W., The Acme Indicator Co.
Smith, E. W. P., 1566 E. 93d Street.
Smith, H. E., G. C. Kuhlman Car Co.
Staats, H. N., Vice-President and General Manager, The American Railway Insurance Co., 208 Electrical Building.
Stanton, George, Cleveland Frog & Crossing Co.
Stanton, Mark T., The Electric Railway Improvement Co.
Stuckenholdt, H., The Whitmore Manufacturing Co.
Sweet, Arthur J., Nelite Works, of General Electric Co.
Vail, G. S., Branch Manager, Westinghouse Electric & Manufacturing Co.
Verner, A. L., Lorain Steel Co.
Ward, Charles W., Electrical Engineer, Steel Tie Specialty Co.
Watson, W. J., Engineer, Bridges and Buildings, Citizens Building.

CLEVELAND — *Continued:*

Weaver, O. T., National Carbon Co.
Whitmore, S. W., President, Whitmore Manufacturing Co.
Williams, E., Manager Street Railway Sales Department, Sherwin Williams Co.
Zulauf, F. H., The Van Dorn & Dutton Co.

COLLINWOOD:

Dean, Dwight B., Sales Manager, The G. C. Kuhlman Car Co.
Smith, Wm. A., Vice-President, The Lino Paint Co.

COLUMBUS:

Ackerman, E. O., Engineer Maintenance of Way, The Columbus Railway & Light Co.
Bone, J. L., Assistant General Manager, The Ironsides Co., 613 Wyandotte Building.
Caldwell, F. C., Professor Electrical Engineer, Ohio State University.
Dail, Wm. A., National Lead Co., 1368 Brighton Road.
Foote, F. J., Master Mechanic, Ohio Electric Railway Co.
Hutchins, S. D., Westinghouse Traction Brake Co.
McCloud, E. H., Chief Engineer, The Kinnear Manufacturing Co.
Schmidt, F. C., Secretary, The Kinnear Manufacturing Co.

CUYAHOGA FALLS:

Ashworth, J. S., Master Mechanic, Northern Ohio Traction & Light Co.

DAYTON:

Buckley, P. F., Ohmer Fare Register Co.
Emmons, N., Jr., Assistant General Manager, The Dayton Manufacturing Co.
Funk, C. V., Ohmer Fare Register Co.
Gebhart, Henry, General Manager, The Oakwood Street Railway Co.
Iddimgs, Roscoe G., Pyrene Company.
Ketteman, C. W., Ohmer Fare Register Co.
Leidenger, Joseph, Eastern Sales Manager, The Dayton Manufacturing Co.
Leidenger, P., Western Sales Manager, The Dayton Manufacturing Co.
Moore, John, The Egry Register Co.
Ohmer, H. Beckman, Ohmer Fare Register Co.
Ohmer, J. F., President, Ohmer Fare Register Co.
Ohmer, W. I., Dayton Fare Recorder Co.
Seeber, Edward, Ohmer Fare Register Co.
Stedman, J. H., Secretary, Ohmer Fare Register Co.

LETONIA:

Crawford, A. A., Superintendent Motive Power, Youngstown & Ohio Railroad.

MANSFIELD:

Beck, C. C., Ohio Brass Co.
Brown, J. R., Ohio Brass Co.
Leibold, C. P., The Ohio Brass Co.
Ohio Brass Co. (The).
Starkey, W. C., Chief Engineer, Ohio Brass Co.
Strail, F. A., Ohio Brass Co.
Tomlinson, C. H., Ohio Brass Co.
Wickwire, E. F., Ohio Brass Co.
Wilkinson, A. L., Ohio Brass Co.

NEWARK:

Besuden, Edwin, The Jewett Car Co.

NILES:

Schall, A. W., Niles Car & Manufacturing Co.

NORWOOD:

Riedel, D., Jr., General Manager and Electrical Engineer, Cincinnati & Columbus Traction Co.

SALEM:

Weeks, C. H., Vice-President, The Buckeye Engine Co.

SPRINGFIELD:

Garlough, R. A., Bayonet Trolley Harp Co.
Olinger, C. S., Bayonet Trolley Harp Co.
Price, E. C., Indianapolis Switch & Frog Co.
Smith, Oscar W., Bayonet Trolley Harp Co.

TOLEDO:

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OREGON

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PENNSYLVANIA

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HARRISBURG:

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JOHNSTOWN:

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RHODE ISLAND

PHILLIPSDALE:

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KOJIMACHI-KU, Tokio:

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Library of Municipal Street Railway of St. Petersburg, Nadejdinskaia 38.

Russian Electro-Technical Congress, Permanent Committee.

BOLIVIA

POTOSI:

Rowe, Geo. H., Engineer and Contractor, Potosi Electric Railway Co.

BRAZIL

PELOTAS:

Gastal, Benjamin, Electrical Engineer, Companie Fiacad & Tecido Peloteuse.

SPAIN

BARCELONA:

Billings, A. W. K., Care of Barcelona Traction Light & Power Co.

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